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A COMMITTEE RETIRES

Within the Institute, committees are formed at an alarming rate. Some produce reports that carry their name and so achieve immortality. Others pass away unrecognised and unremembered, except by a few who have worked with them. There is a danger of this happening to the longest serving committee that the Institute has ever formed.

In 1948 when the Journal came to Melbourne, J. A. Baker, R. D. Croll, H. C. Forster and N. S. Noble, volunteered for, or were drafted onto, the first Victorian Publications Committee. In 1951 Croll became chairman, and P. F. Butler joined, first as Assistant Editor and later as committee man. In the last twelve years while a few other committee men and seven editors came and went, these five stood firm.

Then in the early part of this year, Forster, Butler and Noble retired and Croll stood down from the chairmanship. Throughout these years the Committee acted as a committee should. They gave advice when asked, they seldom interfered and never recriminated when the editor faltered. Jealous of their own role, they stood up for the Journal against Council when they saw fit. I think it is correct to say that they all left their own personal and professional interests outside the committe room and acted there solely in the interest of the Journal as they saw it. That they did not all see this interest in the same way added a spice and a refreshing quality to meetings. In a committee riddled world they were a pleasure to work with.

It is fitting that one of the originals, J. A. Baker, has taken on the task of chairman of the new committee, and fortunate that a new draft of conscripts, P. G. Hyland, A. G. Lloyd, K. Loftus Hills, and L. L. Stubbs, have agreed to serve.

R. N. SANDIFORD.

Articles

THE POTENTIAL FOR AGRICULTURAL DEVELOPMENT AND SETTLEMENT IN THE NORTHERN TERRITORY

H. C. FORSTER

Introduction

Pastoral

The pastoral industry, unlike agriculture, is well established over wide areas of the Northern Territory. It is based primarily on production of store cattle which are transported over long distances to markets on the eastern coast of Queensland or at Adelaide in South Australia. Much is being done on sound lines by the Northern Territory Administration to improve the present rather primitive systems of station management and to increase production. Several excellent surveys have already been made of the cattle industry, stressing the importance of disease control and the need for improved nutrition to increase the appallingly low turn-off of cattle, which ranges from 7 to 15 per cent. The recent increase in beef prices will provide much needed capital for additional fencing and water supplies and will justify the spending of considerable sums of money on improvement of transport.

The further conversion of the present system of management from store cattle to the production of fats however will depend primarily on transport and development of markets in the Northern Territory and on agricultural improvement of the native pastures.

Agriculture

The potential for development of agriculture in the North is important therefore not only in establishing closer settlement for production of cash cropping, but also for producing improved fodders either as pastures or fodder crops for the existing cattle industry.

It was with this background in mind that the Minister for Territories, the Hon. Paul Hasluck, set up in July, 1959, a Committee to look at any potential for agriculture in the North. The present paper will deal largely with the findings of that Committee.

Before we consider in detail this question of the potential for agriculture in the North, we can learn much from a study of the problems of the past. May we look therefore first at some of these.

Professor H. C. Forster is Professor of Agriculture at the University of Melbourne.

He was chairman of the Committee of Enquiry (1959-60) set up by the Commonwealth Government to investigate the agricultural potential of the Northern Territory.

This paper was originally presented at the Symposium "The Challenge of the North" arranged by the Victorian Branch of the Australian Institute of Agricultural Science.

The History of Development

The history of previous attempts to establish agricultural settlement has not been a happy one. The problem is not that a wide variety of plants cannot be grown in the higher rainfall areas of the Northern Territory. The reasons for failure appear to lie rather in economic factors, the lack of markets, poor demand, low prices, and lack of transport. Inevitably producers have been up against a cycle which it was almost impossible to break. A cycle of poor prices because there was no market, no market because there were few people, few people because there was no industry, no industry because of the poor prices. And so the cycle went round and round.

We must remember too that there has been nothing like the gold rush of the 1850s to populate the North as occurred in the South; nothing like the favourable export wool prices of the early 1800s to start a grazing industry. If the North is to be developed, it is quite evident that some major positive action must be taken to break this cycle.

The Area for Development

The second important point that emerges is that the Northern Territory covers a very wide area with very varying climatic conditions. It comprises four main regions—Darwin and the Gulf, Alice Springs, Barkly Tableland, and Victoria River districts.

- The Darwin and Gulf region offers the best prospects for agriculture, with a rainfall of 60 inches on the coast to around 35 inches at Katherine. On the sea frontage the flooded coastal plains extend for some 40 to 60 miles inland, with alluvial flats bordering a number of rivers. Large portions of the eastern region around Arnhem Land are rocky with poor soils and likely to be useless for agriculture. Towards the southern portion of the region there are considerable areas of mixed soil types in the Tipperary and allied land systems near Katherine, some of which are suitable for agriculture. This region is frequently referred to as the "Top End" of the Northern Territory.

- The famous Barkly Tableland region is important for its Mitchell grass plains and for the cattle stations established on it. However, the rainfall of 15 to 20 inches is such that an agricultural settlement would be difficult to maintain, and the development of this region in the future must undoubtedly lie in improvement in management of the cattle stations.

- The Victoria River region in the west has not been thoroughly surveyed, but it has many areas of alluvial and flooded plains which provide excellent pastures for cattle production. However, much of the area is covered by rocky outcrops which hinder the efficient mustering of cattle.

- The dry inland plateau rises to some 2,000 feet, with a series of higher ranges in the centre of the continent. The highest of these reaches 4,900 feet, but as a whole they have little effect in inducing rainfall which totals only 5 to 10 inches per annum. Much of the inland is covered by sparse spinifex with very low carrying capacity of 3 to 4 beasts to the square mile. Appreciable areas are covered by shrubs such as mulga and gidgee which provide good top feed for cattle.

While much of the Territory is quite unsuited for agricultural development, it is evident that there are considerable areas in the better rainfall regions of the Top End that appear to have suitable soil and climate for agriculture. The comments and recommendations of the Committee have therefore been directed chiefly at the development of this region.

The Environment

Much has been said about the unfavourable environment of the North. The climate is important from two aspects (a) the difficulties as far as human habitation is concerned and (b) the difficulties in regard to agricultural farming or livestock production.

The Human Factor

Living conditions in the high rainfall, humid conditions of the Top End present many difficulties to the white men and women who come from the temperate south. It is significant that very few agricultural settlements in the humid tropics of the world have been undertaken by white people. There can be no question however that large populations of native races are being maintained in overseas areas with

similar climatic conditions to those prevailing in the Top End.

The salient point therefore is that the Australian Government must face in the not-too-distant future the challenge that either we develop these more favoured areas with our own people under Australian standards of living or we may find it hard to resist the pressure to let other races come in and develop them under their levels of living.

The Committee was impressed with the number of Australians who preferred to live in the North—as they said "the challenge of this new pioneer country gets under your skin". Not everyone is suited to these conditions, but it is important, if we are to develop the North with Australians, that those who are prepared to go should have reasonable facilities in the way of home and living conditions, roads and services; further, that they be assured of reasonable finance and credit to develop their farms, because no young settler these days can provide the finance necessary to develop this country of the North; and finally, that before the Government permits new settlers to attempt settlement in a large way, it must be convinced that the project has a reasonable chance of being a sound economic venture.

This latter consideration has been foremost in our minds. Not that we have felt bound to look at the prospects of agricultural settlement on the basis of present inadequate transport, facilities and existing markets; but, rather the prospects that might be possible provided some initial assistance was given to the new settlers on the lines adopted by Governments in southern Australia.

Climate and The Plant

So much for the human outlook. Now may we look at some aspects of the environment from the plant's point of view.

Although the rainfall in the Top End varies from 60 inches at Darwin in the north to 35 inches at Katherine, most of this falls within the restricted period from November to April and the climate during the remaining months is very dry. This limits agriculture in the dry country to annual cropping and restricts pasture species either to annuals or very hardy perennials. The length of growing season varies from 24 to 25 weeks at Darwin to between 20 and 21 weeks at Katherine. Moreover, evaporation is high (about 90 inches) and the variability of rainfall at Katherine for instance is 34.5 inches $\pm$ 10.4 (30 per cent), ranging from 16.7 to 70.7 inches.

The variability of rainfall is of particular importance at the beginning and end of the season and failure of rains, particularly at the break of the season, can have a disastrous effect on cropping.

Irrigation

The possibility of supplementing rainfall with irrigation water therefore is of considerable importance and is receiving much attention from the Northern Territory Administration at the present time. Although there are reasonable bodies of water at shallow depths underlying the coastal belt which can be used for irrigating high priced crops of vegetables and fruit, there is considerable doubt as to the possibility of conserving any material quantity of water in surface reservoirs bordering the main rivers. This is of particular importance in potential rice production on the sub-coastal plains as will be referred to later. Some limited potential for irrigation of high priced crops also exists around Alice Springs in underground reservoirs of water in the sandy beds of streams.

But at the moment, it appears that there is no immediate prospect of the development of any major irrigation scheme for the Northern Territory as has been developed for the Victoria Ord region of Western Australia.

Soils

The soils suitable for agriculture in the Top End do not form a large percentage of the total area, but nevertheless in actual acreage they are quite appreciable.

In the naturally flooded sub-coastal plains for instance, the soils are typically deep heavy black clays which border the rivers. The estimate of the area of suitable soils for rice production ranges from 500,000 to 750,000 acres. Much of this however borders the rivers and is quite inaccessible to roads at the present

stage, so that there is a huge problem of transport facing the authorities in developing these regions. The second major development zone lies in the dry-land Tipperary System, near Katherine where pasture improvement and annual cropping to peanuts or grain sorghum present possibilities. The soils vary considerably, from red loams of reasonable fertility to light spewy silts and sands of low fertility. Although the total area of the Tipperary System is quite large, there are many rocky outcrops. A more intensive survey is being undertaken by C.S.I.R.O., but some estimates of the area of suitable soils range from 10 to 20 per cent only of the total area.

Some Other Problems

Land Clearing

A major problem which must be faced in establishing an agricultural settlement in the North is the initial task of land clearing. The natural timber is mainly eucalypt occurring in a fairly open woodland savannah. It varies from fairly heavy, tall trees on the coast to light timber in the Katherine region. Although the original price of the land is negligible, clearing, fencing and watering under conditions prevailing in the North are quite costly. Although normal clearing in the past has been by bulldozer, there appears to be no reason why introduction of large scale clearing by chain as developed in southern Australia should not reduce costs considerably. The fallen timber, however, does not burn readily and extra raking and windrowing may be necessary. Suckering is also a more serious problem than in the south. Experiments are needed therefore to define the best methods of clearing and trials have already been initiated.

Costs have been assessed by the Committee on the basis of work already carried out. The figures indicate that the initial clearing, burning and ploughing would cost £9 to £10 per acre. Such preparation would be adequate for pasture establishment. However, for intensive cropping with peanuts, additional clearing of stumps and sticks would bring the total cost of preparation to between £14 and £15 per acre. It is important to recognize then that agricultural settlement will involve large capital costs.

Transport, Fertilizer and Other Costs

Considerable stress must be laid on the many servicing difficulties handicapping the settlers in the North. All goods must be brought long distances by road, sea, or air, adding considerably to their initial cost. The port of Darwin is not equipped for bulk handling and charges for unloading and transhipment are heavy. As one example, superphosphate which is just as essential for the North as is it for southern Australia costs £24/15/0 a ton landed at Darwin compared with £12/13/0 a ton in the south. The Committee was impressed with the possibilities of Christmas Island rock phosphate dust as an alternative. Even this would cost £16 a ton in 1,000 ton lots plus wharfage charges of £2 a ton to land at Darwin.

Here once again we come to the vicious circle of high prices because of low demand, low demand because no agricultural industry exists at present. The Committee recommended strongly that if agriculture was to be established in the North, consideration should be given to subsidizing, in the initial stages, freight and handling charges on important items such as superphosphate.

Recommendations of the Committee

There are many other problems which must be faced in attempting settlement in the North, but perhaps these may best be dealt with in relation to recommendations submitted by the Committee.

On the basis of the present available evidence, the Committee looked closely at three potential types of agricultural settlement,

1. Sown pastures for cattle fattening in the Top End
2. Rice on the sub-coastal plains and the Marrakai
3. Peanuts on the Tipperary Land System.

1. Sown Pastures for Cattle Fattening in the Top End

The Committee was impressed with the possibilities of improving the natural pastures in the Top End and the use of these for fattening cattle for local consumption and export overseas. The existing cattle industry is well estab-

lished and is well adapted for producing good store cattle cheaply. Although there are no large abattoirs at Darwin at the moment, there is every prospect that Vestey's will build new abattoirs at that centre for the local market, and if a sufficient number of fat cattle were forthcoming it would not be asking a great deal for the works to be enlarged to undertake export killing as well.

The export of live cattle to Hong Kong has been rather spasmodic over the years, but there appears to be no reason why this should not also be developed on a sounder basis. The demand is primarily for forward store cattle rather than fats and this is the type that the Top End should be able to produce very cheaply.

The work of C.S.I.R.O. has demonstrated the value of improved pastures of Townsville lucerne *(Stylosanthes)* and buffel *(Cenchrus)* grass in supplementing the natural pastures and is most impressive.

The mechanical procedure of clearing and sowing down these improved pastures still needs much investigation. The present estimate of costs runs as high as £14 per acre but preliminary trials indicate that it may be possible to sow down Townsville lucerne in amongst the standing timber. This should reduce costs materially.

However, assuming that complete clearing is desirable, the Committee attempted an overall assessment of the economics of cattle fattening under these conditions. On the assumption that store cattle could be bought at 6d. per lb; that a market for improved fat cattle was available at 7d. per lb; and that the beasts put on 270 lb of weight over the 12 months, the cattle fattener would possibly break even after allowing for costs, interest on capital, and an owner-operator's allowance of £2,000 p.a. The proposition is therefore attractive when one considers the likelihood of receiving more than 7d. per lb for better quality cattle (prices at Wyndham and Townsville are normally better than 7d.) and the prospects for increasing the annual weight gain above 270 lb.

2. Rice on the Sub-Coastal Plains and the Marrakai

The establishment of a rice industry on the sub-coastal plains of the Northern Territory presents many interesting features. The initial attempt by Territory Rice Limited has provided much valuable information upon which we believe a more successful rice industry can be based.

The problem of dry seeding will still remain as a major hazard since there appears to be little prospect of supplies of irrigation water at seeding. Recent experiments by C.S.I.R.O. however have been conducted with the seeding of rice in a wet seed bed after the initial break in the season—"puddling" as it is called overseas. This may well provide a means of reseeding the "failed" areas from the earlier dry seeding.

Avoidance of "sun cracking" of grain at maturity by spreading the period of harvesting is important. This involves growing the rice in smaller unit acreages, artificial drying, and the breeding of rice varieties combining high yield and variable times of maturity.

But the most important factor underlying successful establishment of a rice industry must lie in increased yields per acre. An average harvest of 10-15 cwt of paddy per acre can never be an economic proposition. When we remember that the average yield of the Murrumbidgee Irrigation Area is 45 cwt and more of paddy per acre it is not asking too much to expect that the yield at Humpty Doo can be increased.

The Committee prepared budgets for rice farms of 250 and 500 acres respectively. Based on world export prices of fair quality grain giving a return at Darwin of £25 per ton of paddy, we have estimated that a grower would be able to pay costs of production, interest on capital and owner-operator's allowance of £2,000 p.a. provided that yields of approximately 20 cwt per acre of paddy were obtained on the 500 acre farm and about 23 cwt per acre on the 250 acre farm.

Since yield per acre is so vital, the Committee strongly recommended that if rice production was to be established it should be

grown on individual farm units of these acreages rather than on large-scale extensive farms of the type established by Territory Rice Limited.

3. Peanuts on the Tipperary

Much thought and research have been directed to the growing of peanuts in the better soil regions of the Top End. There is no doubt that climatic conditions are suitable to the growing of peanuts at Katherine and C.S.I.R.O. surveys have shown that there are considerable areas in the Tipperary Land System around Katherine that would be suitable for large-scale production of peanuts on a dry land basis.

However, at this stage, insufficient information has been obtained on the exact location and extent of these suitable soils and on the mechanics of large-scale peanut cultivation and production on the farm. This is now being obtained by further surveys in the Tipperary Land System and by large area field production on the Northern Territory Administration Experiment Farm.

Furthermore, considerable uncertainty exists as to the potential market for any new large-scale production unit. Since the market for edible nuts in Australia is oversupplied now, the Committee looked at the possibility of crushing peanuts for oil and exporting this on the world market. The residual peanut meal from such a process would find a ready market as a concentrate in any cattle fattening projects.

Once again hypothetical budgets were prepared for typical farms growing 200 acres of peanuts. Allowing for a rotation of two years of peanuts and one year of some alternative fodder crop, we concluded that a farmer would be able to produce nuts (after paying costs, interest and an owner-operator's allowance of £2,000 per annum) at a cost of about 6d. per lb provided average yields of 1,200 lb nuts in shell per acre were obtained and peanut meal was sold at £35 per ton. If we compare this yield with the average production at Kingaroy (about 900-1,000 lb per acre) and if we contrast the price of 6d. per lb at Katherine with the overseas price of between 4d. and 5d. per lb for nuts used for oil production, it is evident that the producer at Katherine will have some difficulty in establishing himself unless he can get special sidelines to help him.

The Problems of an Agricultural Settlement

Land Tenure

Although some freehold areas of land have been granted to settlers over the years, the general pattern of land tenure has been based on leasehold. For instance, in 1959 apart from reserved and unoccupied land the area of land held under freehold comprised less than one-half of one per cent of the total area of the Northern Territory. While leasehold form of tenure appears to be well suited to large pastoral holdings, it presents some problems as far as closer settlement is concerned.

Special Agricultural Leases have been introduced from time to time in the Northern Territory for the small agricultural holdings around Darwin, Katherine and Alice Springs. However, the general conditions attaching to these are not popular and this form of tenure has not encouraged much development of agriculture.

More recently Agricultural Development Leases were introduced to cope with the large-scale development proposed by Territory Rice. These provided for development of the land by the Company over a period not exceeding 30 years and subsequent allocation of portions of the area to individual settlers under Agricultural Lease.

It appeared to the Committee that the type of leaseholds adopted so far have not been well suited to agricultural settlement. Where material improvements are to be made to the land, it is difficult to assure the settler of the security of his just rights in such improvements. Furthermore, where the final value of the developed property depends as it does in this pioneer stage so much on the initiative, enterprise and agricultural "nous" of the settler, it is only possible to ensure that this so-called "unearned increment" passes to the settler in a freehold title.

The Committee recommended strongly therefore that a freehold form of land tenure should be introduced to encourage agricultural settlement. It is of interest to note from a recent

statement by the Minister for Territories that the Government had decided to introduce this.

Finance

From the comments that have already been made, it is apparent that the Committee believed that agricultural settlement could be successful only if it were attempted on fairly large-scale, fully mechanized farms owned by individual settlers. Our figures indicate that the capitalization involved in each single holding will run at about £40,000 (apart from livestock) in the cattle fattening proposition, about £30,000 for the rice farm, and about £20,000 for the peanut farm.

It is obvious then that large organizations, whether government or private are necessary to sponsor settlement and undertake initial development. We felt that the ultimate ownership of the individual blocks should pass to one-man or two-man operators, but that the initial clearing and development could best be undertaken on a large scale.

Adequate long-term credit, under suitable supervision, must also be available to the settlers during the initial stages of settlement.

Pilot Farms

Because of the large investment necessary and the lack of initial experience of farming in these new areas, the Committee recommended that in the first case the Government should set up pilot farms as test areas. Experimental stations and research centres can do much to determine the best agricultural practices, but the final determination of the best economic farm system and the true cost of production can only be obtained by actually running a farm.

The pilot farms therefore would be run by individuals who would be allotted to a farm unit which had been initially developed by the Government. The individual would be paid a wage during the test period and would be required to run the farm on general broad lines laid down by the settlement authority, but he would not be directed as to how he does it. He would therefore be able to use his initiative and drive in determining the best management system. He would, in addition, be given an incentive in the form of guaranteed prices for his agricultural products, these prices being based on a price which is thought to be attainable in the future. Finally, if the test is satisfactory and settlement proves possible, the pilot farmer should be entitled to compensation in acquiring his block at a reasonable figure.

At the present stage, the Committee recommended that pilot farms should be initiated by the Government in sowing improved pastures for cattle fattening and in rice production. When more information is available other types of pilot farms could be initiated.

The Settlement Authority

If the Government finally decides to go ahead with the development of agricultural settlement, much thought must be given to the administrative organization to carry out such development.

After reviewing the various types of settlement schemes in Australia, the Committee recommended that a Land Development Authority should be set up, separate from any Government Department, on lines somewhat similar to the Closer Settlement Authority in Victoria.

In the initial stages of land clearing and early development of blocks, it is essential if costs are to be kept to a reasonable figure to use modern large-scale methods and equipment operating over large areas. An efficient organization with adequate finance, free from the many restrictions which inevitably harass Government Departments is therefore required.

Much care must also be given to the selection of settlers for the new settlement. There is considerable merit in the practice adopted by the Victorian Settlement Authority in giving preference to those men who have taken part in the initial clearing and development of the blocks.

Services

The Committee has been impressed with the importance of adequate research, investigation and extension services. Many problems may arise which could make or mar the whole settlement project. It has not been easy to

attract or retain Government scientific and technical staff in the Territory. Special consideration must be given to making the Northern Territory Administration an attractive service, not only from a salary point of view, but also in the more important task of providing adequate facilities and conditions under the rather exacting climate of the North.

Conclusions

This very brief account of our survey of the potential for agricultural settlement in the Northern Territory presents some of the many problems that must be overcome before success can be assured. We concluded that there were good possibilities for agriculture in the North, *but,* and this is a most important but, agricultural settlement cannot hope to be economic if it has to face the present difficulties of lack of transport and markets, difficulties of high costs in handling, high wharfage handling charges, and high fertilizer costs. If the North is to be developed, it will be paramount that someone must be prepared to make available capital in large slabs, so that initial clearing and development can be undertaken on a large scale.

Summarizing the findings of the Committee, we can say that on the basis of our assumptions, the best prospects for immediate settlement lie in:

The introduction of improved sown pasture associated with cattle fattening, provided an export market from Darwin can be established.

The growing of rice on individual holdings on the sub-coastal plains.

To provide further information on costs and farm scale production methods the Committee recommended that pilot farms be established for each of these types of settlement before the final decision on large-scale settlement is made.

In closing may I stress that we cannot afford another failure in the Northern Territory. Australia has many other things on her plate in the way of potential areas for agricultural development in more favoured climatic zones.

The final decision must rest with the Commonwealth Government. A successful agricultural settlement is not likely to just happen in northern Australia. It will demand careful planning and the concentrated effort of scientists with ability and foresight. It will require settlers with initiative and drive and above all courage and faith in the future. But surely the challenge is one we as Australians should take up, a challenge not for the Government only, but one for the nation.

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SOME ASPECTS OF THE CHEMICAL COMPOSITION OF PASTURE HERBAGE IN RELATION TO ANIMAL PRODUCTION IN NEW ZEALAND

G. W. BUTLER and
A. T. JOHNS

The herbage of pasture plants is of variable composition for a number of reasons. The mineral composition is strongly dependent on soil type. Different species may contain characteristic differences in levels of common mineral and organic constituents and in addition unique secondary substances such as alkaloids or cyanoglucosides may be present. Also, composition is affected by maturity of the plants and by seasonal changes. It is therefore not so surprising that nutritional disorders, arising from deficiency, excess or imbalance of this or that constituent, should be seen in grazing animals, particularly when their feed is confined to one or two plant species. This paper deals briefly with some aspects of the complex subject of plant-animal relationships which are being studied at Plant Chemistry Division, Grasslands Division, and Massey Agricultural College.

Iodine Nutrition

For several years we have been interested in the iodine nutrition of grazing animals, from two points of view. It was found (Johnson and Butler 1957; Butler and Johnson 1957) that the total iodine content of herbage of various pasture species and strains (which were growing in a randomised layout on the same soil) ranged from 7 to 146 μg per 100 g dry weight. Differences in the herbage iodine content of single plants within strains of the ryegrasses were observed to be large and when diallel crosses were made of perennial ryegrass plants it was shown by analysis of the progenies that the herbage iodine content was a strongly inherited characteristic. The nutritional implication of this finding is that the dietary iodine intake of grazing animals might be expected to be strongly dependent on botanical composition, as well as soil factors.

It was also shown (Flux, Butler, Johnson, Glenday, and Petersen 1956; Butler, Flux, Petersen, Wright, Glenday, and Johnson 1957) that when white clover was fed to guinea-pigs and rats, the uptake of iodine to their thyroid glands was retarded. This is known as a goitrogenic effect and evidence was obtained which supported the view that two chemical constituents of white clover known as cyanoglucosides (linamarin and lotaustralin) were responsible. Hydrogen cyanide is released from these cyanoglucosides as the feed is digested and this is then detoxicated to thiocyanate in the liver (Blakely and Coop 1949). Thiocyanate is known to competitively inhibit the absorption of iodine by the thyroid gland, and it was shown that an appreciable inhibition was obtained when thiocyanate was dosed to small animals in quantities sufficient to raise the blood thiocyanate content to levels comparable to those found in sheep grazing white clover. A similar inhibition could be shown in slices of excised sheep thyroids (Butler *et al.* 1957).

During the last four years, this work has been followed up with two field experiments with sheep, in collaborative work between the Sheep Husbandry Department of Massey

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Agricultural College, and the Plant Chemistry and Grasslands Division, D.S.I.R. The experiments were carried out on a paddock scale on a total area of 16 acres, in a randomised layout. Four different types of pasture were established on the area, namely:

Perennial ryegrass
Short-rotation ryegrass
Perennial ryegrass and white clover
Short-rotation ryegrass and white clover.

Since short-rotation ryegrass herbage had been shown to contain only one-fifth of the iodine of perennial ryegrass when growing on the same soil and since the white clover had been shown to have a goitrogenic effect, animals grazing these pastures might be expected to have markedly different iodine nutrition.

In each trial, the pastures were stocked with ewe-hoggets in May of the first year. The paddocks were set-stocked throughout each trial, the minimum carrying capacity being 6 ewes per acre. Where necessary, extra sheep were brought on to the area to control excess growth. The ewes were mated in the second year of each trial and their lambs raised to weaning stage. All animals were slaughtered in December of the second year of each trial. Half the animals on each pasture type were given an iodine supplement in the form of "Neo-Hydriol", an iodinated poppy-seed oil, injected intramuscularly. This dose was sufficient to raise the blood iodine level three or four-fold and to hold it at that level for at least 12 months. Differences in liveweight gain, wool production and fertility were examined for the iodine-injected and non-injected animals on the four pastures, and at slaughter the thyroid glands of the ewes and their lambs were weighed and analysed for total iodine.

The results of the first trial have been described in detail elsewhere (Flux, Butler, Rae, and Brougham 1960). In both trials, no differences in animal production were observed. No cases of congenital goitre occurred in the lambs. The thyroid data proved particularly interesting and the mean weights for the different groups are summarised for both trials in Table 1. It will be seen that the goitrogenic effect of the white clover was quite pronounced in the first trial, but negligible in the second trial.

An unexpected development was the presence of goitrogenic effects in animals grazing the pure ryegrass pastures, the most marked being noted in the lambs grazing short-rotation ryegrass in the second trial. These effects were not due to a few animals with very large thyroids, but were overall group effects. It is clear that factors other than those so far considered are also important in regulating the iodine nutrition of sheep and lambs on pasture and experiments are currently in progress to endeavour to elucidate these.

These experiments were carried out during four years in which goitre did not occur in sheep in the district. It is probable that the effects would have been larger in "goitrous" years.

TABLE 1

Mean thyroid weights (grams) for ewes and lambs grazing four pasture treatments (N.I. = not injected with Neo-Hydriol, I. = injected with Neo-Hydriol).

Treatments	Perennial		Short rotation		Perennial + White Clover		Short rotation + White Clover	
	N.I.	I.	N.I.	I.	N.I.	I.	N.I.	I.
First trial								
Ewes	7.6	4.2	5.9	5.3	9.0	5.2	12.7	5.1
Lambs	2.4	1.6	2.2	2.2	6.0	4.3	5.4	2.5
Second trial								
Ewes	9.1	6.0	8.0	6.0	9.0	6.7	7.5	7.5
Lambs	2.2	2.5	10.8	2.6	3.2	3.2	3.9	3.2

Nutritive Value of Pasture Plants

Although no differences in animal production, which could be ascribed to differences in iodine nutrition, occurred in the above trials, large differences in growth rate were seen between animals on the four pastures. In both trials differences in the growth rate of the ewes on the various pasture treatments became apparent at an early stage and continued throughout. For example, Figure 1 shows the divergence in mean liveweight for the various groups of animals during the first nine months of the second trial. It will be seen that a difference of 25 lb had opened up by the end of this period between the animals which had grazed short-rotation ryegrass plus white clover throughout and those which had grazed pure perennial ryegrass. The liveweight gains on the other two treatments were intermediate between these two extremes.

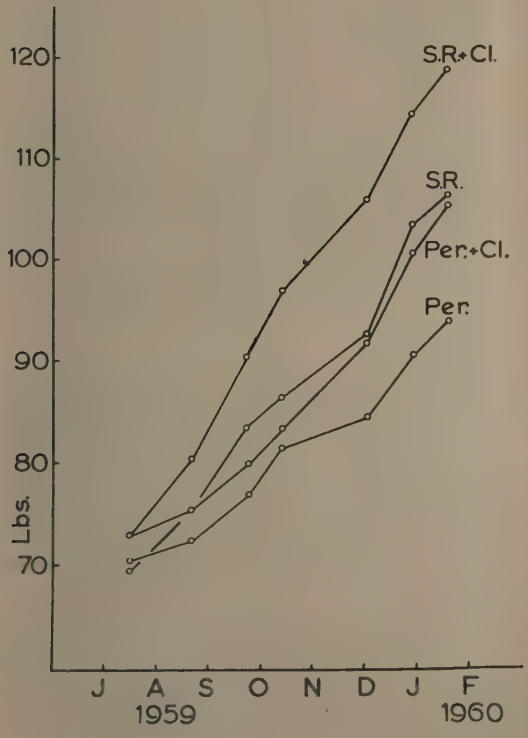

Figure 1—Mean live weights for the four groups of animals during the first 9 months of the second trial. Per., perennial ryegrass; S.R., short-rotation ryegrass; S.R. + Cl., short-rotation ryegrass plus white clover; Per. + Cl., perennial ryegrass plus white clover.

A feature of these results was the general agreement between the first and second trials and also between individual replicates of the treatments in each trial.

The finding of such large differences in nutritive value of the different feeds obviously could have important implications. When a detailed examination was made of the carcass composition at slaughter it was found that in general differences in carcass composition followed differences in growth rate—with one important exception: the weight of rumen contents was appreciably greater in the case of animals grazing perennial ryegrass than in the other treatments. It would appear that an understanding of the salient features of the ruminant physiology of animals on the different treatments is necessary, and some preliminary measurements were made on animals slaughtered at the end of the second trial.

In Table 2, data are given for the final live weights and carcass weights of ewes at slaughter, as well as the weight of rumen contents and the content of volatile fatty acids in the rumen liquor.

In the weight of rumen contents there is a highly significant difference between grasses, with the addition of clover making little difference. However, addition of clover to the diet had a significant effect in the concentration of the products of microbial digestion, the volatile fatty acids, while the difference between the grasses was less marked. Hence the animals that have grown the fastest, on short-rotation plus clover pastures, have actually the smallest forestomachs and the highest level of fermentation at time of slaughter. Intake measurements have not been made, but from what is known from other recent work it is highly probably that appetite increased in the order perennial ryegrass, perennial ryegrass plus white clover, short-rotation ryegrass, short-rotation ryegrass plus white clover. It is evident that the animal with the slower fermentation rate can in part compensate for its lower fermentation rate by a more capacious rumen. In the case of the short-rotation plus

TABLE 2

First Trial (1957-58)

Data obtained from ewes (78) and lambs (55) fed entirely on the four types of pasture.

	Perennial ryegrass	Perennial ryegrass + white clover	Short-rotation ryegrass	Short-rotation ryegrass + white clover
Final live-weight ewes (lb)	103	119	116	136
Carcass weight (lb)	56.2	70.2	74.7	81.5
Av. daily weight gain of lambs (lb)	0.30	0.40	0.38	0.47

Second Trial (1959-60)

Data from 60 ewes fed entirely on the four types of pasture. Mean values for rumen contents and volatile fatty acids (V.F.A.) from 8 ewes of each group.

	Perennial ryegrass	Perennial ryegrass + white clover	Short-rotation ryegrass	Short-rotation ryegrass + white clover
Final live-weight ewes (lb)	97	125	120	137
Carcass weight (lb)	41	59	61	69
Rumen contents weight (lb)	11.7	10.5	8.1	8.1
V.F.A. (mM/100 ml)	11.8	13.4	12.3	14.7

white clover not only will there be more acid produced, but it will have to be absorbed more rapidly from the smaller organ. Although there is large variation in each group, it was found that the papillae which provide the absorption area in the rumen were in general better developed in the animals grazing short-rotation ryegrass plus white clover than in the animals grazing perennial ryegrass.

Of the individual volatile fatty acids, it is known from other work that when they are used as a source of energy in the fattening animal, acetic is used with an efficiency of 33 per cent, propionic 55 per cent, and butyric acid 62 per cent (Blaxter 1959). It is therefore of interest that in the present work, the short-rotation plus clover group was significantly lower in acetic and significantly higher in both propionic and butyric acids than the perennial ryegrass group. The relative contribution of the clover and the ryegrasses to this difference still has to be determined. It is evident, however, that the short-rotation ryegrass plus clover pasture produces, besides a more intense fermentation in the rumen, a mixture of acids that are more efficient in producing weight gain than are those formed from perennial ryegrass.

This subject has recently been discussed in greater detail elsewhere (Johns 1961).

Selenium

Over the past three years, there has been considerable research activity involving selenium in New Zealand. Workers at Wallaceville Animal Research Station, and Lincoln Agricultural College (Drake, Grant, and Hartley 1959; Hartley, Grant, and Drake 1960; McLean, Thomson, and Claxton 1959) have shown that small quantities of selenium given to sheep either orally or intramuscularly as sodium selenate or sodium selenite lead to beneficial effects in many areas of the country —remission or prevention of white muscle disease, improvements in fertility and improvements in rate of growth of the animals.

It is obviously important that the various facets of the selenium cycle in New Zealand grasslands should be well understood and a number of research laboratories are at present

tackling aspects of the problem which relate to their own particular interests and skills. At Plant Chemistry Division Petersen and Butler have examined the uptake and metabolism of selenium by plants and also the form in which selenium is excreted in dung.

The selenium content of pasture herbage in New Zealand is very low, being of the order of 0.01 to 0.1 p.p.m. dry weight, which is 100-1,000 times less than the average content of trace elements such as copper or zinc. Chemical determination of selenium in such small amounts presents experimental difficulties which have, however, been overcome by New Zealand workers (Cousins 1960; Watkinson 1960). So far, however, it has only been possible to determine chemically the total selenium content of the tissues. This has the limitation that all the selenium determined may not be nutritionally available; it is therefore desirable to know the chemical forms of combination of selenium in the plants.

Radioactive selenium affords a sensitive and convenient method of examining this question. The radioactive material is obtained as sodium selenite of high specific activity (10,000 mC per g) and it can therefore be added to nutrient solutions at levels which are not far removed from the natural conditions in New Zealand and which are certainly well below levels at which toxic effect on plants would be seen. After a suitable period had elapsed for the uptake of radio-selenium and its assimilation into various compounds, the plants were harvested and subjected to chemical fractionation. The distribution of radioactivity in various compounds was then investigated.

Species from three plant groups have been chosen for examination:—

(a) A representative of the selenium accumulators. These are plants which are capable of absorbing selenium to quite high levels and which grow on seleniferous soils, i.e. soils with a high selenium content. We have used *Neptunia amplexicaulis,* a legume which is restricted to seleniferous soils in central Queensland, and for which selenium levels as high as 4,000 p.p.m. have been found (McCray, private communication). Furthermore, selenium would appear to be beneficial for the growth of this plant, since when *Neptunia* is grown in vermiculite with A.R. grade nutrients there is a definite response to selenium (McCray, private communication).

(b) A representative of an intermediate group of plants, which can contain moderate amounts of selenium (up to 50 p.p.m.) without marked toxic symptoms. Such plants do not normally have such a high selenium content but can tolerate reasonably high levels without showing toxic effects. Wheat was the species chosen.

(c) Some pasture species (containing 0.01-0.1 p.p.m. Selenium)—white clover, red clover, and perennial ryegrass.

The results obtained from the three groups of plants showed marked differences in the distribution of radioiactivity, as shown in Table 3.

Whereas with leaves and stems of *Neptunia,* 90 per cent of the radioactivity can be extracted in boiling aqueous ethanol, with wheat herbage only 20 per cent of the radioactivity can be extracted in boiling aqueous ethanol and water. With herbage of pasture plants also, a large fraction of the radio-

TABLE 3

The percentage distribution of selenium-75 in the alcohol-soluble, water-soluble, and residual fractions of herbage from various plants.

	Neptunia	Wheat	Ryegrass	White clover	Red clover
Alcohol-soluble	92	18	19	28	34
Water-soluble	4	5	3	4	4
Residue	4	77	78	68	62

activity is not extracted by aqueous ethanol and water.

With regard to the nature of the extractable radioactivity in the herbage interesting differences were found between the different plant species. In the two graminaceous species, wheat and ryegrass, selenite was the predominant component with small amounts of other compounds, which appear to be analogues of sulphur amino-acids, being present. With *Neptunia,* which is a legume, selenite was the component present in greatest concentration, but appreciable quantities of two organic selenium compounds were also present. With both white and red clover herbage, selenite was a minor component and several analogues of sulphur amino-acids were identified.

In the case of the large amounts of unextractable radioactivity found in all herbage samples except *Neptunia,* most of this radioactivity can be brought into solution by incubating the extracted plant residues with the proteolytic enzymes trypsin and chymotrypsin. Seleno-analogues of sulphur amino-acids can then be identified in the enzymic hydrolysate. It would therefore appear that the major portion of the radioactive selenium taken up into leaves of these species became associated with protein. This is substantiated by the fact that when preparations of soluble protein are made directly from wheat plants which have been allowed to absorb labelled selenite there is appreciable labelling of the soluble protein. It is possible that some of the selenium compounds, however, may be bound to the protein by loose linkages (such as salt linkages) rather than by peptide linkages.

It is interesting to speculate that the tolerance of *Neptunia* to high levels of selenium is relative to the relatively small tendency for protein binding of selenium in this plant. From a nutritional point of view, it would appear that the major portion of selenium ingested by a ruminant would be associated with protein or amino-acids.

Excretion of Selenium

During the course of this work, Dr. Cousins of the Otago Dental School advised us that there was a high faecal excretion of selenium given orally to sheep as sodium selenite. When a dose of 5 mg was given, 40 per cent of the selenium was recovered in the dung in 72 hours. This observation is important, since previous reports of experiments with non-ruminants had indicated a predominantly urinary excretion. It suggests that much selenium may be rendered unavailable to the animal in the digestive tract.

We have confirmed this observation at a lower dose-level, namely 12 μg selenium, by the use of radioactive selenite. This is the sort of level which an animal would ingest daily. Fifty per cent of the administered radioactivity was recovered in 3 days from the dung of two sheep, which were allowed to graze normally after injection of radioactive selenite into the rumen. By similar techniques to those used for the plant fractionation studies, it has been found that:—

(a) Less than 10 per cent of the selenium is soluble in water or organic solvents.

(b) Approximately half the radioactivity is dissolved by proteolytic enzymes.

(c) The remainder is readily soluble in bromine water and is apparently in insoluble inorganic form.

The availability to plants of the selenium present in the dung from selenium-dosed animals would appear to be an important point to establish for our understanding of the selenium cycle in grasslands. Accordingly perennial ryegrass is at present being grown on mixtures of sand and radioactive dung and the extent of uptake of radioactive selenium by the plants determinied. To date, negligible amounts of radioactivity have been found in the herbage.

Genetic Variations in Herbage Constituents

In the breeding of herbage plants, one of the principal aims should be to develop improved varieties which are not only productive (in terms of yield per acre per annum, or seasonal yield), but also of optimum chemical composition from the viewpoint of ruminant metabolisim. For pasture species which are the subject of intensive selective breeding programmes, it is therefore desirable to assess the extent of genetic variations in various chemical

constituents which are considered to have nutritional significance.

Some experiments along these lines have been carried out at Plant Chemistry and Grassland Divisions with the ryegrasses. As mentioned earlier, it was shown that the total iodine content of ryegrass herbage was an inherited characteristic capable of large variation.

A more extensive experiment has recently been completed, in collaboration with Dr. P. Barclay, Grassland Division, in which seven plants derived by hybridisation from perennial and short-rotation ryegrasses have been examined for herbage contents of a number of mineral constituents. The plants were laid out as clones in a randomised layout, so that variations due to soil and environment could be allowed for.

It was found that nitrate levels varied up to ten-fold among the seven parent plants. The differences between parents in this regard were maintained over a twelve months period. Smaller significant differences (up to three-fold) were found for sodium, calcium, manganese, aluminium, copper, titanium, iron, zinc, sulphate and acid-soluble phosphorus. No significant differences in potassium levels were observed.

Some interesting interactions were found between the levels of a number of the mineral constituents and between values obtained for the same plants for the root cation exchange capacity. This quantity was determined by Mr. M. Mouat of Grassland Division, and varied by a factor of 1.5 for the seven plants.

Total correlations were first calculated and then decomposed into genetic and environmental correlations. Significant positive genetic correlations with cation exchange capacities were observed between differences in the levels of the polyvalent cations aluminium, titanium and iron. Significant negative genetic correlations with cation exchange capacities were observed between differences in nitrate and acid-soluble phosphorus levels. This is to be expected on the basis of Donnan equilibria, if the physico-chemical step from soil solution into the roots was the rate-limiting step in the process of uptake of these five minerals by the plants. In this connexion, it should be pointed out that the analyses were made on herbage which had been sampled when the plants were in a state of rapid growth and when the demand on soil nutrients would presumably have been greatest. Some other significant genetic correlations which showed up are not unexpected from the plant physiological literature, for example a negative correlation between iron and manganese, and a positive correlation between potassium and calcium.

Growth of these plants was also determined at (or near) times of harvest of herbage for analysis. In no case so far examined has variation in a particular plant constituent been correlated genetically with differences in herbage production of plants. This emphasises the point that the assessment of the nutritive value of plants being used in the development of new strains requires detailed chemical servicing.

Differences in the levels of the alkaloid perloline were also examined, since this constituent is also of interest from the point of view of ruminant nutrition (Cunningham and Clare 1943). Perloline levels varied up to 50-fold amongst perennial ryegrass parent plants; with the seven plants used in the preceding experiment the values ranged from 8 to 264 mg perloline per 100 g dry weight.

To sum up, genetic differences in herbage levels of nitrate, iodine and perloline are ten-fold or greater in ryegrass parent plants, and smaller variations occur for a number of other constituents. It is clear that the work should be extended to other chemical constituents and pasture species. This work is at present being prepared for formal publication.

"Autumn Ill Thrift"

In New Zealand, there is often a marked acceleration of grass growth in the autumn, coinciding with warm moist conditions. Clarke and Filmer (1956, 1958 a, b) have observed that "autumn flush" grass growth coincides with losses of weight in grazing sheep. Hoggets are particularly prone, leading to the condition known as "hogget ill thrift". The outstanding feature of this metabolic dis-

order appears to be a loss of appetite, with the animals starving in the midst of plenty.

Chemical studies of rapidly growing autumn ryegrass have been made at Plant Chemistry Division. The most obvious characteristic of the chemical composition of such herbage is the comparatively high content of non-protein nitrogen compounds (and in particular of inorganic nitrate) coupled with a relatively low level of soluble carbohydrates. Nitrate fluctuations have been examined in some detail; as would be expected from the plant physiological literature, the nitrate content of pasture is affected by a great variety of factors and is subject to violent changes (Butler 1959). With respect to the possibility that continued ingestion of sub-lethal amounts of nitrate in rapidly growing autumn ryegrass could be responsible for "hogget ill thrift", a considerable amount of circumstantial evidence has been collected to support the view that nitrate reaches maximum levels in grass on which animals are suffering from "autumn ill thrift". When all the evidence is taken into consideration, however, (Butler 1959) it appears unlikely that nitrate can be more than a contributor to the overall condition; and it is possible that it is only an indicator of potential stock trouble.

Interest has therefore turned to other non-protein nitrogen constituents of herbage, particularly a basic function which appears to be present in maximal amounts in rapidly growing material. It has also been realised that the rumen biochemistry resulting from ingestion by the animal of such high nitrogen/low carbohydrate feed may exhibit novel features which are deleterious nutritionally, such as amine production. A long-term assessment of these possibilities is projected.

Bloat

Bloat is a confusing entity, much more complex than has been generally realised, in which both plant and animal factors play a part. Research on bloat has been carried out at Plant Chemistry Division over the past ten years on both aspects of the problem. The main findings of this group have been summarised in reviews by Johns (1956, 1958). The contribution that possible plant factors make to the state of the bloated animal is discussed here.

There have been a number of theories concerning bloat, where it was believed that toxic factors in the plant material, or produced from plant material by bacterial fermentation, inhibited rumen movement or the eructation mechanism or caused systemic poisoning.

The factors incriminated at various times have been the cyanogenetic glucosides of white clover, saponins, histamine, anticholine esterases, smooth muscle inhibiting flavones, nitrate, ammonia, ammonium carbonate, hydrogen sulphide, alkalinity, and lack of fibre. However, several workers are agreed that in animals examined with bloat, the rumen is in active movement, (Wester 1935; Weiss 1953; Johns 1954; Lindahl, Davis, Jacobson, and Shaw 1957). It was difficult to determine whether the strength of the movements is in any way reduced, but recent work at this laboratory suggests that there is no reduction in the strength of rumen movements at least in mild bloat.

The results of a number of workers show quite clearly that the primary cause of the majority of cases of bloat is not an inhibition of rumen motility *per se*, but rather the retention of a greater part of gas within the rumen ingesta.

Acute bloat has been produced by oral or intraruminal administration of pressed juice from legumes and attempts have been made to correlate the foaming capacity of legume juice with its bloating potential, for example Ferguson and Terry (1955). However, Mangan and Johns (1957) found no significant differences between the foaming properties of macerates produced from herbage of widely differing bloat-inducing potencies.

As outlined by Johns (1956) the type of foam present in the rumen is of the surface viscous type, of which protein and saponin foams are typical examples. These are incompatible with non-viscous foams formed by soaps and detergents.

McCandlish (1937) was the first to suggest that plant saponins were a contributing

factor in bloat whilst Johns (1954) has suggested that proteins could be important from the point of view of their foaming properties. These will be considered in turn:—

Saponins

Lindahl *et al.* (1954) were the first to produce bloat by dosing a saponin isolated from a pasture legume (lucerne). However, it appears doubtful whether the condition resulting from the dosing of saponins is similar to that obtained during legume bloat. In cases where death occurred *post mortem* examination has indicated that death was associated with an intense sub-mucosal and subserosal haemorrhagic condition of the gastro-intestinal tract. Such lesions are not obvious in deaths from pasture bloat.

The evidence is conflicting on the possibility that there is a correlation between the saponin content of forage and its ability to produce bloat. Thus while the work of McClay and Thompson (see Cole, Dougherty, Huffman, Hungate, Kleiber, and Maclay 1956) indicates the possibility of such a correlation, Barrentine (1960) found no relationship between the saponin content and the bloat potential of 5 legume species. A major limitation in testing the role of saponins is that there is no simple method available for measuring the day-to-day fluctuations in saponin levels.

Mangan (1957) determined the pH optima for maximum foam stabilitiy for a saponin fraction from red clover and a sample of lucerne saponin. For both of these, the optimum is in the region of pH 4.5-5. There was very little foam stability at pH 6 which is the pH optimum for maximum foam stability of rumen contents from bloating cows (Mangan 1957). On this evidence it would not appear likely that saponin as such plays much part in producing foam in the rumen. However, more work is needed to determine whether saponins or the products from their microbial dissimilation can be incriminated in any way in the genesis of bloat.

Protein

Ferguson and Terry (1955) have pointed out that bloat can develop in 15-30 minutes after the commencement of grazing and the bloat provoking principle must therefore diffuse out of the plant material rapidly. These authors go on to say that it is doubtful if much of the ingested protein would be released from unchewed tissues within this time. However, sufficient does escape rapidly into the rumen to form a stable foam (Lyttleton, Mangan, and Reid, unpublished results). In results obtained in this laboratory (Mangan, Johns, and Bailey 1959) it has been found that when the degradation of protein in the rumen is somewhat inhibited by dosing with penicillin, the soluble protein nitrogen can rise from 12 mg to 38 mg of protein N per 100 ml one hour after the commencement of feeding. Even in an untreated animal feeding on red clover the rise was from 3.9 mg N before feeding to 19.3 mg N per 100 ml in 1 hour after the commencement of eating. Mangan (1959) has also found that in the presence of salt the red clover cytoplasmic protein at a concentration of 20 mg protein N per 100 ml formed a very stable foam with a maximum stability at pH 6.0, and that the foaming potential of rumen liquor parallels the changes in concentration of protein.

It appears that the conditions in the rumen and protein concentration after feeding are such that plant protein could play a part in the production of a stable foam.

Antifoaming Agents

In a study of the action of penicillin in preventing bloat, it was found that the antibiotic had a profound effect on the foaming properties of rumen contents (Mangan *et al.* 1959). Foam expansions and foam stabilities of the crude rumen liquor from a penicillin-treated cow were found to be very low compared with those of the control animal. This was in spite of the fact that the treated animal's rumen liquor had a very high soluble protein content. By contrast the *centrifuged* rumen contents from the treated cow showed a very high foam strength. This very great increase in strength of the foam produced from the centrifuged rumen liquor of the penicillin-treated animal (in agreement with the high soluble protein content) as compared with

the strength of foam from the crude liquor, indicated that a strong antifoaming agent was present and was removable by centrifuging. It had been postulated (Mangan 1957) that the plant chloroplasts, with their envelope of lipid, have antifoaming properties and that the results obtained in centrifuging rumen contents are due to their removal from the liquor.

It appears possible that the degree of foaminess of rumen ingesta is in part at least determined by the particular ratio of foaming to antifoaming agents present.

Other Chemical Compounds

In contrast to the opinions of Quin (1943) and Rosen *et al.* (1956), studies by Mangan and Johns (1957) failed to show a correlation between either soluble sugars or organic acids and bloat.

Conrad, Pounden, Bentley, and Feelter (1958) found that washed lucerne fibre produced *in vitro* on an average three times the amount of gas obtained with an equal weight of lucerne juice. They claim that the plant substances responsible for the initial rapid gas production obtained with green lucerne are closely associated with the fibre fraction and are removed by extraction with hot water. They conclude that the stable foam found in pasture bloat is due to the combined effects of the physical structure of lucerne fibre, pectic substances of lucerne, galacturonic acid obtained by the hydrolysis of pectic substances and reducing sugars. A possible weakness of the *in vitro* work of Conrad *et al.* (1958) is that the rumen ingesta used were from animals fed on grain and hay. This diet may well have produced a rumen microbial population more favourably disposed to the digestion of fibre and starch than the soluble constituents of lucerne juice.

The observations of Conrad *et al.* (1958) are not consistent with those of others who have suggested that the non-fibrous portion of the plant is more important in the etiology of bloat. The results of Boda and Johns (in the press) indicate that the plant substances responsible for the initial gas production after the ingestion of legumes are associated with the plant juices. They obtained no indication that pectic substances are important in foam formation. Bloat is not believed to be due to rapid gas production *per se,* but when the gas produced is being retained within a foam extra gas will be an additional embarrassment to the animal.

Recent work by Boda and Johns would indicate that the foaming potential of the animal's stomach before feeding is of considerable importance in determining whether the animal will bloat when fed. This would point to the feed eaten on days previous to bloat being important in determining the bloat proneness of the animal. The plant constituents which influence the state of the rumen in this manner have not been investigated.

Conclusion

The main conclusion to be drawn from the work summarised in this article is that while a start has been made much remains to be done.

It is also obvious that the consideration of plant-animal relationships is a vast and profitable field for study, both for purely scientific and for practical agricultural reasons.

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PUBLIC SERVICE OF SOUTH AUSTRALIA

Applications for the position set out hereunder, marked confidential and addressed to The Director of Agriculture, Gawler Place, Adelaide, will be received until and including 15th OCTOBER, 1961.

Applicants should state full names, address, date of birth, marital status, academic qualifications, practical experience, and give particulars of war service (if any). Copies only of testimonials should be submitted with the application.

The appointee may be required to contribute to the Government Superannuation Fund.

Department of Agriculture
BEEF CATTLE ADVISER

Salary: Commencing salary will depend on qualifications and experience. Assured progression to £1,950 per annum, with opportunities for promotion to £2,080 per annum and higher.

Duties: Plan and supervise investigational projects in all aspects of beef cattle husbandry both on private properties and liaison with departmental research centres; survey existing practices both in pastoral and farming areas; organize and assist in extension programmes with farmers and graziers.

Qualifications: A degree in Veterinary, Rural or Agricultural Science is essential and some practical experience in the cattle industry desirable.

THE ECONOMIC SIZE OF FARMS

A. G. LLOYD

This paper reviews recent trends in farm size, discusses the causes of those trends, the relationship between size and efficiency, and some aspects of government policy as related to farm size.

Farm size can be measured in many ways, but here we concentrate attention mainly on acre size, despite the fact that an acre of land is a very variable unit. In Australia, at least, long term statistics are not available for many of the other units of measurement, and in any case, acreage size determines how many farms can exist, which is a major political question.

Trends in Farm Size

Admittedly averages can be very misleading, but in terms of average acreage Australian farms are probably the largest in the world, to judge on the following figures (Black 1953):

> Japan 3, Greece 9, Switzerland 15, Denmark 39, England 82, U.S.A. 215, Argentina 266, Canada — 119 (Ontario) 408 (Saskatchewan).

The Victorian average in 1955-56 was 545 acres (Table 1). It is true that land quality in Australia may be below average, but in terms of output per farm also, Australia ranks very high.

TABLE 1

Average Farm Size—Victoria 1906-1956.

Year	No. of Holdings	All Farms Total Area '000 acres	Average Area acres
1906	54,275	34,519	636
1929	74,912	38,371	512
1948	70,910	39,345	541
1956	69,528	37,856	545

Note: Unfortunately we cannot compare the size distribution over time, since there was no satisfactory classification of Victorian farms by acreage size until 1948.

Source of Information: Commonwealth Statistician.

Throughout a large part of the world, farm size has decreased as population has risen. Fragmentation of holdings has been particularly marked in countries not having primogeniture (inheritance by the eldest son), and is still occurring at a serious rate in parts of Asia. Cutting across this relationship between farm size and population, farm size has been increasing in some of the advanced countries.

United States

U.S.A. average farm size has risen steadily from 136 acres in 1890 (2.0 workers per farm) to 175 acres in 1940 and 215 acres in 1950 (1.6 workers per farm). There has been a fall in the number of large tenant plantations and large estates operated by hired labour, and this has been partially offset by a long-term increase in the number of small farms (many of them part-time and residential farms near the cities). The third factor has been a trend towards larger medium-sized farms, associated with the development of mechanisation.

Australia, Late Nineteen-Twenties to 1948

There are no statistics showing long-term trends in farm size on an Australia-wide basis, but a similar pattern of events to the U.S.A. appears to have occurred in N.S.W. and Victoria (apart from the long-term increase in the number of small farms).

In these two states there was a small increase in average farm size between the late 1920's and 1948. However, changes in

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averages frequently conceal more than they reveal. In N.S.W. (Gruen 1949) the relatively small increase in average farm size was the net result of two very definite and counteracting trends:

1. A tendency for large estates to be split up;

2. The smallest farms were generally declining in numbers as a result of amalgamation.

These two trends led to a growth of medium-sized farms, both in numbers and in the proportion of the total land area occupied. Similar changes occurred in the size of sheep flocks.

It seems likely that the same two developments occurred in Victoria between 1929 and 1948. Certainly the average farm size increased during this period (see Table 1) but we cannot be sure what lay behind this change in the average, since there is no satisfactory classification of Victorian farms by size groups until 1948. There is some indirect evidence in Table 2, which shows that between 1910 and 1956 the proportion of Victorian sheep run in "large" flocks (over 10,000 sheep) fell from 20 per cent to 3 per cent and the proportion run in "small-medium" flocks (1,000 to 5,000) rose from 31 to 49 per cent. True, there was an increase in the proportion of sheep run in flocks of 500-1,000 which does not support the hypothesis that as in N.S.W., there was a decline in the number of small farms; but this could be explained in terms of more small sideline flocks on wheat farms, following longer rotations.

1948-1956

More recently different trends have emerged though they may be short-lived. Between 1948 and 1956, in both N.S.W. and Victoria, the increase in average size of holdings was halted, despite the continuance of the break-up of large estates.

Previously, in N.S.W. (excluding Western Division) both "small" holdings (under 1,000 acres) and "large" holdings (over 20,000 acres) had been declining in importance relative to the "medium-sized" groups: in 1948-56 however, small holdings increased in importance, and the "large-mediums" (5,000-20,000 acres) as well as the large estates, declined (Spinks and Gruen 1958).

In Victoria, virtually the same changes occurred; all size groups from 50 to 5,000 acres increased in importance (i.e. in percentage of total holdings and percentage of total area) and all size groups over 5,000 acres declined (see Table 3).

What explanations can be offered for the relative preponderance of amalgamation in the decades preceding 1948, and of subdivision in 1948-56?

In the earlier period, the depression of the thirties and the manpower shortages of the forties forced many farmers to sell out. Mechanisation probably played only a very limited role in forcing larger farms, since the

TABLE 2

Number of Sheep and Percentage of Sheep in each Flock Size Group. Victoria, 1910-1956.

	1910		1929		1948		1956	
	No.	%	No.	%	No.	%	No.	%
Under 500	2,614,051	20.29	3,602,345	21.83	3,833,085	21.44	3,840,184	16.48
500-1,000	2,267,722	17.60	3,584,454	21.73	4,296,458	24.03	5,901,914	25.34
1,001-2,000	2,100,701	16.30	3,493,346	21.17	4,277,266	23.92	6,760,013	29.02
2,001-5,000	1,918,515	14.89	3,029,857	18.37	3,198,694	17.89	4,635,668	19.90
5,001-10,000	1,427,575	11.08	1,563,323	9.48	1,387,366	7.76	1,481,661	6.36
10,001-20,000	1,474,982	11.45	981,485	5.95	645,666	3.61	556,764	2.39
Over 20,000	1,081,820	8.39	216,875	1.31	238,127	1.33	112,499	0.48

Source of Information: Commonwealth Statistician.

TABLE 3

Changes in Size of Rural Holdings, Victoria 1947-48 to 1955-56.

Size (Acres)	1947-48				1955-56			
	No. of Holdings	%	Area of Holdings	%	No. of Holdings	%	Area of Holdings	%
1-49	17,118	24.14	342,941	0.87	14,486	20.83	308,184	0.81
50-99	7,692	10.85	555,551	1.41	7,609	10.94	552,661	1.46
100-199	11,521	16.25	1,635,705	4.16	12,387	17.81	1,750,435	4.62
200-499	14,840	20.93	4,771,939	12.13	14,876	21.30	4,777,673	12.62
500-699	5,887	8.30	3,519,941	8.95	6,137	8.83	3,660,816	9.67
700-999	4,829	6.81	4,044,385	10.28	5,053	7.27	4,227,109	11.17
1,000-1,999	5,995	8.45	8,251,645	20.97	6,059	8.72	8,298,274	21.92
2,000-4,999	2,345	3.31	6,711,384	17.06	2,376	3.41	6,874,876	18.16
5,000-9,999	445	0.63	2,980,900	7.58	381	0.55	2,500,316	6.61
10,000-19,999	144	0.20	2,005,186	5.09	95	0.14	1,300,933	3.44
20,000 plus	94	0.13	4,525,025	11.50	69	0.10	3,605,198	9.52
TOTAL	70,910	100.00	39,344,602	100.00	69,528	100.00	37,856,475	100.00

Source of Information: Commonwealth Statistician.

rapid expansion of mechanised farming did not commence until the post-war years.

The 1948-56 period featured rare prosperity and the "pasture improvement revolution"—a favourable climate for subdivision, especially when compared with current conditions. Some subdivision doubtless occurred within families, to minimise income tax and death duties.

The decline in the importance of large estates in both periods resulted partly from the Closer Settlement policies of State Governments, partly from death duties and Federal and State Land Tax and partly from market pressures towards a more efficient use of land. Estimates have been made suggesting that in N.S.W. *private* subdivision was responsible for the major portion of the decline of large holdings in the 1948-56 period (Spinks and Gruen 1958).

Economies of Scale

People who know little about agriculture commonly express puzzlement as to why, when modern technology requires that manufacturing firms be very large to achieve efficiency, the typical farm firm remains a one, two, or three-man business. They are assuming that there must be "economies of scale" in agriculture as well as in manufacturing—i.e. opportunities to reduce average costs by increasing the size of the business.

And indeed there are economies of scale in agriculture, as evidenced by the increase in farm size in some advanced countries over recent decades. But the answer seems to be that they can be fairly fully exploited without making farms very large, and that there are important *diseconomies* if farms are made very large.

In manufacturing, *division of labour or job specialisation* results in an important economy of scale. In large businesses, workers can be employed to specialise on tasks for which they have greatest ability, and constant practice thereafter increases that ability.

In agriculture, job specialisation has some efficiency advantages, even when practised in a small way. For example, in one four-man partnership on a 9,000 acre property in Gippsland, one partner specialises on machinery and clearing, one on crops and pasture, one on livestock management, and the fourth runs an adjoining small irrigation unit and keeps the books. But job specialisation pays greatest dividends for regular and fairly continuous routine tasks, such as milking on a dairy farm;

and for most farm jobs there is no "sequential flow pattern", no passing of raw materials along an assembly line surrounded by stationary workers. At any one time there may be six jobs which urgently need doing, or one job on which all hands are required; once done there may be little to do for some time, and some of the jobs will not be done again for another year.

With or without specialisation, *labour economies* can be of some importance. For many types of farms, doubling the area cropped or the livestock carried requires less than double the labour. Doubling the number of milking cows may involve less than double the labour used in milking and will certainly not double the time involved in cleaning up. On larger farms, a smaller proportion of labour time is expended in preparation for the job and putting away machinery. Finally, many farm jobs can be done more efficiently with two men than with one, with three men than with two.

Marketing economies, such as bulk discounts, can also be important both in purchasing and selling, and large properties provide the opportunity for more efficient grading and standardisation.

But the most important source of economies of scale, particularly in cropping, is *efficiency in the use of plant and machinery*. First, the smallest size in farm machinery and plant is usually not the most *efficient,* defining efficiency as low average cost per unit of output. Secondly, using a given size of machine, a large farm will usually achieve lower machine costs per unit of output than a small farm because it can more fully utilise the machine, i.e. it can spread overhead costs over a larger output.

It is the mechanisation of agriculture that has made farm size an important determinant of efficiency. In countries where labour is cheap and agriculture is not mechanised, farm size does not greatly affect cost per bushel of wheat, per ton of rice, etc. But the substitution of machinery for labour makes overhead costs more important, relative to running costs, and for this reason low-cost production can only be achieved with a larger acreage, which permits lower machinery investment per acre. Mechanisation becomes economic as labour becomes more expensive, as it has in the advanced countries. Therefore it is hardly surprising that it is the advanced countries which have shown some tendency towards larger farms.

A farm should be large enough to permit full utilisation of the more expensive machinery items. But what is meant by "full"? We can illustrate by examining the tractor costs of wheat-growing, using the following assumptions:

1. A medium-size tractor involves *overhead costs* of £200 per annum (interest, depreciation, insurance) the whole of which is charged to cropping.*
2. *Cash running costs* (fuel, oil, repairs and maintenance and the labour of the driver) total 30/- per acre per annum, covering five operations—ploughing, two harrowings, sowing, and harvesting.
3. The tractor is big enough to handle 400 acres of crop adequately in virtually all seasons, averaging 30 bushels per acre, but if 800 acres per annum are attempted, operations are frequently not done at the ideal time, and average yield drops to 24 bushels.

Adding overhead and running costs per acre and converting to a per bushel basis gives the results shown in Figure 1.

The following points are apparent:

1. As crop acres are expanded a point is reached where running costs per bushel commence to rise, as a result of declining yields.
2. As the area cropped increases, overhead costs per bushel fall very steeply at first, then more gradually. Adding 100 acres to a 200 acres per annum programme lowers tractor overheads per bushel by 2/7 from 8/- to 5/3, but adding 100 acres to 800 acres gives no significant reduction.

*As a reasonable approximation, depreciation is assumed to be little affected by the variation in annual usage assumed here, but repairs and maintenance (coming under running costs) will be affected.

3. Adding running costs and overheads gives a U-shaped average cost curve, which shows the minimum-cost point at B, i.e. tractor costs per bushel are lowest where approximately 500 acres per annum are cropped, and this is what might be termed "full' utilisation. This figure of 500 acres will vary considerably with tractor size, soil type, and climate.

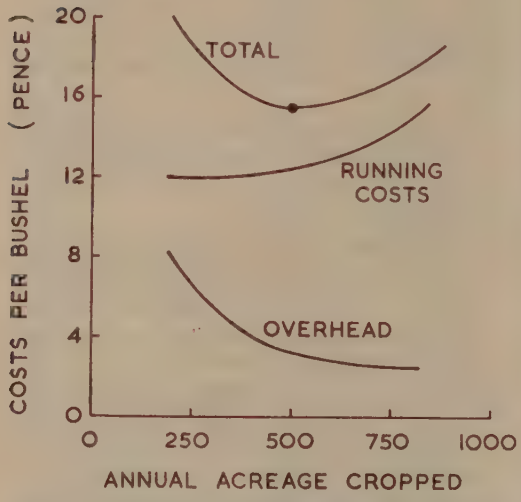

Figure 1.—Tractor costs of wheatgrowing — medium tractor (hypothetical).

Of course other plant and machinery besides tractors must be taken into account, particularly the more expensive items, such as the header, and the hay baler, but the same principle will hold, viz., *with a fixed set of plant, increased output initially permits a great reduction in overhead costs per unit of output, but a point is reached where this cost reduction becomes relatively unimportant, and is outweighed by higher running costs as the plant is over-taxed.*

The pick-up baler provides another example. Increasing annual hay output greatly reduces overhead costs per food unit conserved, though a point is reached (around the 400 tons per annum mark) where the overhead cost reductions from further expansion become rather unimportant. At some point they are outweighed by the cost effects of declining hay quality as the hay-making season is extended. There is a decline in food units and protein units per bale, which increases running costs per nutrient unit. Many farms are too small to permit full utilisation of a pick-up baler, as we define "full" here.

But surely, it might be argued, on a farm which is too small for 500 acres of crop per annum, high overheads are avoided by using a smaller tractor. True, but a smaller tractor is technically less efficient. Figure 2 depicts this situation, where a farmer cropping only 250 acres would be operating at lower costs with a smaller tractor than a medium tractor, but at higher costs than if he were cropping 500 acres with a medium tractor. A large tractor *might* enable further cost reductions, if the farm were big enough to fully utilise it, but very large tractors are only more efficient for particularly heavy jobs.*

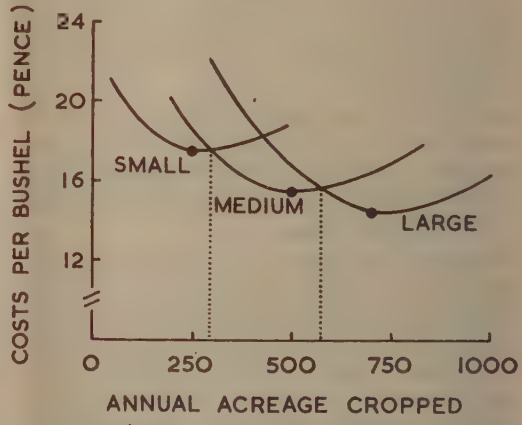

Figure 2.—Tractor costs — Small, medium and large tractors (hypothetical).

This raises the question of *multi-purpose versus specialised machinery.* Versatility in machinery is frequently at the expense of efficiency for particular jobs. A single multi-purpose tractor which is too light for some jobs and too heavy for others is a compromise small farms cannot escape.

Small farms usually, of necessity, have small paddocks, and this is another source of inefficiency in machine use. In a valuable survey

*Incidentally, Figure 2 shows the break-even points, at which it pays to switch from small to medium tractor, or medium to large in this given hypothetical situation.

of machinery and labour utilisation in the northern Mallee, Molnar (1960) measured the importance of this factor. He found that savings of £12/7/0-£14/3/0 per 100 acres of crop could be expected when the length of run was increased from 10 to 30 chains and paddock area was increased from 50 to 150 acres.

A further advantage of large farms is the opportunity they offer for profitable diversification. There are certain minimum limits to the size of a profitable sideline, and on a large holding each of a number of enterprises can be operated on a reasonably efficient scale.

We can visualise the cost curves for small, medium and large farms (not only wheat farms) as being very similar to the curves for small, medium and large tractors in Figure 2. A small farm can increase production and spread overheads by using more labour and capital per acre, and for a time this lowers average costs per unit of output; eventually however, following the law of diminishing returns, average costs per bushel, gallon, etc., commence to rise (beyond point A), because each extra 100 bushels or 100 lb butterfat requires more fertiliser, fuel, feed, and labour.

The medium-sized farm faces the same problem, but because of the size advantages discussed above, its point of minimum cost (at B) is lower than the corresponding point (A) for the small farm. Similarly, the large farm is more efficient than the medium-size farm (C is below B) *but not by much.* What I am suggesting is that *the medium-size (say two-man or three-man) farm has a considerable cost advantage over the small one-man farm, especially in cropping, where mechanisation is most important, but the large farm has only a slight advantage over the medium-size unit.* In fact, the very large farm may have *higher* unit costs including the cost of the land it uses, than the medium-size unit. Not only do the economies of scale mentioned "peter out" fairly quickly as size increases, but diseconomies develop.

Diseconomies

In agriculture, when farms become really large management becomes much more difficult, without any significant compensations. In manufacturing, management can be more easily delegated as size increases, and there are compensations, particularly through division of labour and the efficiency of larger plant and machinery. The fact that agricultural machines must be *mobile* sets a limit to the achievement of greater efficiency by larger machine size.

Expansion in manufacturing can take place under the one roof, but in agriculture it involves larger areas, and therefore greater difficulty in effectively supervising men and machines, and longer haulage distances to and from the central point—for machines, produce, and raw materials.

Close and continuous supervision of a considerable number of hired hands is impossible, and checking the workers' performance by results is difficult or impossible for many jobs. Mistakes generally show up immediately on an industrial assembly-line, but in agriculture they often are discovered belatedly or not at all.

In manufacturing, most of the physical processes of machine production can be standardised, and need relatively little supervision, but in agriculture we are dealing with biological processes—with living things. These processes are seriously affected by changing natural conditions and are not well suited to remote, automatic control and delegated responsibility. Rapid adjustment to changing conditions involves *keen observation,* not always exercised by hired labour, and often, *quick, on-the-spot decisions*—not a feature of corporate-type farms with their chain-of-command. (Lack of interest by hired labour on large farms can be partly offset by profit-sharing and bonus schemes, which culminate in share-farming.) In corporation-type agriculture, delegation of management to sub-managers carries with it the weaknesses of absentee management, isolation from the practical details of operations and slow and mechanical administrative procedures. The high average costs which result when the business unit becomes too large have been termed "the dinosaurus effect", to connote excessive size of body in relation to brain, resulting in inefficiency and extinction.

For the individual farmer, managerial ability (including not only technical knowledge, but administrative ability and business sense) is

all-important in determining optimum farm size. Many farmers who do quite well on small specialised farms do not have the decision-making and supervisory ability to efficiently manage medium-size units, whilst the skill necessary for low-cost production on very large farms is, in my opinion, quite rare.

One of the principal difficulties of management of large farms—one which administrative skill cannot much ameliorate — is the *inflexibility of the labour supply*. Hired labour works a specified number of hours a day, after which overtime rates operate, whereas daily labour requirements vary widely through the season on most farms. On family farms, labour is generally prepared to work long hours at peak periods, with compensations in slack periods. On large properties, it usually needs careful organisation to keep hired labour fully occupied in slack periods (at least on fully developed farms), and often workers must be employed on relatively unproductive jobs which do not return the wages paid. Thus hired labour is costly both in peak periods, because of overtime, and in slack periods, because of low productivity. By contrast, labour productivity is relatively high on the family farm, because of labour flexibility and the incentive provided by inheritance or some more direct form of profit-sharing.

The Family Farm and the Home Maintenance Area

It is fortunate that the family farm has some claims to economic efficiency, otherwise its considerable political appeal would pose a real problem. The family farm, and in Australia the related concept of the "home maintenance area", is part of our culture—a sociological institution as well as an economic basis for agriculture. The view is often advanced that democracy flourishes most in a society based on family-farm agriculture, and that large-scale farming would result in a serf-type agriculture.

The Rural Reconstruction Commission (1944) mentioned the "political, emotional and traditional" causes of pressure for land ownership, and suggested that "land ownership implies a freedom from interference and a continuity of existence on one property". That may be putting it too baldly—it is difficult to say what land ownership *does not* imply in the minds of the more romantic urban dwellers; or in the minds of many farmers for that matter, to judge on the land prices paid, or on the living standards tolerated by farm families on the poorer farms. To the security and personal independence which help to enshrine land ownership we might add two other ideals which seem to motivate the land-hungry—the social status conferred by land ownership, and the opportunity of escape from urban tensions and pressures.

But whatever the explanation the effects are clear. Non-economic considerations, the "way of life" aspects of farming, tend to lower farm size, first through raising land values, and second through political opinion favouring sub-division, as evidenced in governmental Closer Settlement Acts and progressive Land Tax.

The strong desire for land ownership and the accompanying security of tenure induces some tenants and sharefarmers to undertake ownership prematurely, before they have sufficient capital, so that they transfer from being tenants on farms of efficient size to owners on farms of inadequate size. The virtual absence of equity financing in agriculture means that the size of farm is limited by the size of the prospective farmer's deposit.

Over many decades concern has been expressed that the family farm is in danger of liquidation, owing to the supposedly greater efficiency of large-scale mechanised farming, and to the increased capital requirements for getting started in farming. At the beginning of the century dedicated saving from wages was a common method of getting started in an agriculture where little more than the land was needed, and where the "living area" was much smaller than would be tolerable at the living standards of today.

Up to the present, however, the family farm shows no sign of decline. For example, there has been no swing away from family farms in the U.S., where approximately 95 per cent of

farms would fall within this category* (Efferson 1953). Similar figures are not available for Australia, but we can obtain some indication of trends by looking at the composition of the rural work force. A trend away from family farms would be reflected in an increase in the proportion of hired labour in agriculture. Yet the statistics show the reverse: throughout the thirties hired labour made up 40 per cent of the work force in Australian agriculture, and this declined to 36 per cent in 1960.

It seems then, that size advantages are not great enough in most segments of agriculture to endanger family-size farms, and that few economies of scale are achieved by expanding farms beyond the point where a family can do most of the work. But there is an important qualification—if the family farm is to retain its relative efficiency it must grow in size as mechanisation increases the acreage the family can efficiently handle. And, in fact, this is what has been happening. On the other hand, against labour saving mechanisation we must set some of the "land saving" techniques such as pasture improvement, which tend to *reduce* the size of farm that a given labour force can handle.

Australian land settlement policy has been based on the concept of the "home maintenance area", generally referred to as a "living area", and defined by the Crown Lands Consolidation Act of N.S.W. as follows:—

> "An area which, when used for the purpose for which it is reasonably fitted, would be sufficient for the maintenance in average seasons and circumstances, of an average family".

The definition is hardly precise, since the size of a "living area" will clearly depend on how well one lives, but clearly it is envisaged as a *one-man* family farm. It is generally recognised that the "home maintenance area" set up following World War I erred on the side of frugality. The more recent settlement schemes have been more liberal, but I suggest that "home maintenance areas" are still smaller than is required for minimum-cost production.

The large family farm, employing at least two men, apparently has the advantages of the small family farm (labour flexibility, incentives, uncomplicated administration) and some of the advantages of the large corporate farm (labour specialisation, the most efficient sizes of machinery, low per acre overheads for buildings and plant) without the disadvantages of either. Empirical corroboration is not easy to obtain; it involves detailed and complicated economic research. A simple comparison of the performance of different size groups is not satisfactory, since other differences besides size are usually associated with the different size groups (for example, quality of land and of management). However, the general conclusion from overseas studies is that the large family farm realizes higher returns per unit of labour and capital and produces at lower unit costs than do small family farms or large corporate units.

Almost certainly the Australian home maintenance area involves some sacrifice of efficiency in land use. The community may judge this sacrifice worth while in the interests of various social goals. But such a judgement can only be soundly based if we know *how much* efficiency is sacrificed and *how much* our living standards are affected, by preferring one-man to two-man units. Therefore some economic research into this question would be highly desirable.

If we decided to promote two-man farms, we would face the problem that Closer Settlement, particularly Soldier Settlement, is concessional—most soldier settlers have regarded their success in the ballot as being equivalent to winning a major lottery. One must sympathise with the desire of Closer Settlement Authorities to distribute public largesse as widely as possible.

Low Income Farms

We in Australia are fortunate that we have no *major* policy problems of low income farms. We have pockets of poverty, particularly in dairying, but nothing on the scale prevailing in say, the United States of America or the United Kingdom. But since we do have some

*Based on the definition of the family farm as one which is (i) small enough so that at least one-half of all the labour required in the growing and production operations prior to harvesting is performed by the farmer and his family, and (ii) large enough so that at least one-half of the gross income of the farm family is derived from the farm.

low income farms, and may want to do something about them, it is worth reviewing overseas policy measures.

In the United Kingdom, considering full-time farms only, 65,000 farms (20 per cent of full-time holdings) can be classified as low-income farms because of inadequate size (O.E.E.C. Report 1960). These farms are eligible for assistance under the Small Farmer Scheme, which came into operation in April, 1959. This scheme is based on grants (maximum £1,000 per farm) linked with farm management advice from the Advisory Services, and aims to assist small farm businesses which are fundamentally economic but are at present handicapped by low incomes.

In the United States of America in 1954 nearly one-half the farms had net incomes from all sources under 2,000 dollars—a bare subsistence income. These farms are most numerous in the south-east in certain areas of dense rural settlement, where there are few outside jobs, and where topography, lack of capital and other physical and institutional obstacles hamper the use of modern farming methods. Government action has concentrated particularly on general area and community development programs(such as T.V.A. and the Small Business Administration program) together with credit, advisory and educational services under the Farmers' Home Administration.

It is noteworthy that both the U.K. and U.S.A. measures to assist small farms represent an insignificant proportion of the total assistance given to agriculture (less than 0.5 per cent of price support operations) but represent a significant assistance to a particularly needy category of farmers.

Price supports and subsidies go mainly to the wealthy farmers—for example, in the U.S. in 1954, 12 per cent of the farms accounted for nearly 60 per cent of sales of farm products. If, for social and political reasons, it is desired to help and protect a particularly needy group within agriculture, there are grounds for preferring direct and constructive assistance specific to that group rather than general assistance to the industry in the form of higher prices and subsidies. This suggestion has implications for the form of assistance we in Australia give to our low-income dairy farmers.

Assistance to low-income producers should not be confined to increasing their productivity *within* agriculture. If the small farmers with least potential can be encouraged to leave agriculture (by direct grants, vocational training and the creation of alternative local employment) they make a two-fold contribution to the economy; they increase their own productivity by the transfer, and they permit increased productivity by farm amalgamation. It is vital for the welfare of farm families that technological advance in agriculture be accompanied by fewer and larger farmers—at least so long as productivity increases faster than demand. The drift to the cities is not an unmitigated evil.

Size Inefficiencies in Australian Agriculture

In view of the many historical factors, institutional and accidental, that have determined the size of our farms, and the obstacles in the way of adjusting size to changing conditions, it would be extremely odd if every farm were of the most efficient size for the managerial ability of the particular farmer. (This is a different question from whether farms are large enough to provide adequate incomes.) How much size inefficiency is costing us must remain a matter for speculation, but there are a few scattered pointers indicating that it might be considerable.

For 1955-56 the Victorian Statistician has provided a size classification for the wheat crop of the State. It shows that 25 per cent of the state acreage was in crops less than 200 acres, 18 per cent in crops of 200-300 acres, 18 per cent in crops of 300-400 acres, and only 39 per cent in crops larger than 400 acres.

From this I would hazard the suggestion that over one-third of the Victorian wheat crop is grown under conditions of marked size inefficiency (after making a guess to allow for contracting and machinery-sharing, which permit escape from heavy overheads). Furthermore, 25 per cent of the state crop was

grown on holdings smaller than 800 acres—insufficient to allow annual crops of reasonably efficient size, except on one-in-two rotation. Molnar's study in the cereal-producing Northern Mallee indicated that an increase in farm size would significantly increase the efficiency of utilisation of machinery and labour.

As far as the dairying industry is concerned, the recent Committee of Enquiry reported that "In four states there are problems of farm size, and no doubt they exist to a smaller degree in Victoria and South Australia". Amalgamation of small holdings was suggested, under a scheme similar to that employed in the reconstruction of the marginal wheat areas in the thirties, with special credit facilities offered to farmers to assist them to acquire nearby farms.

The B.A.E. 1953 Dairy Survey provides some evidence of size economies in dairying. In Victoria there was a close negative correlation between farm size and average cost per lb of commercial butter over the six groups; the largest farms (annual output exceeding 15,000 lb commercial butter) had an average cost approximately one-half that of the smallest producers (under 5,000 lb). The largest farms showed much higher labour productivity, carrying twice as many cows per labour unit.

However, such evidence is not conclusive (though in this case it is very suggestive). Quite apart from the difficulties of cost estimation, there is the likelihood, for instance, that efficient farmers prosper, and own large farms, so that the large farms are efficient, not merely because of their size, but because of their management. In which case, we could not assume that increasing the farm size would necessarily increase efficiency. Nevertheless, my own opinion, based on hypothetical budgets in West Gippsland, is that a typical one-man dairy farm is likely to have average costs 15-25 per cent higher than a similarly managed two-man unit, largely because of the effect of lower overheads per unit of output.

Government Intervention

Where size inefficiencies exist, the necessary adjustments to farm size are largely outside the powers of the individual farmer. Yet it is politically unrealistic to expect *direct* government intervention to secure those adjustments unless some degree of crisis exists—as, for example, when size inefficiencies are so serious that the "low-income farm" problem is critical. Direct government intervention occurred in Australia in the thirties in the adjustment program implemented in the wheat industry.

Where the inefficiencies are not resulting in widespread hardship, democratic governments are likely to restrict themselves largely to indirect measures. In Australia, the most important indirect policy measure has been progressive land tax; direct intervention has been mainly limited to the resumption and subdivision of the very large estates. The large estates resumed in Victoria represent less than 2 per cent of the land in rural holdings.

Insofar as these two measures (Closer Settlement and Land Tax) have affected economic efficiency (they are also directed towards socio-political goals) my guess is that the effect has been favourable, on balance. However, it must be conceded that progressive land tax is a very blunt and indiscriminate weapon in encouraging optimum farm size, ignoring as it does, type of land-use and individual managerial efficiency.

Credit policy could be more widely used to promote size efficiency. Most criticism of rural credit facilities in Australia concentrates on the inadequacy of medium-term *development* credit. Nevertheless, credit for *land purchase,* to permit the expansion of one-man farms could be a more valuable use of scarce funds in many cases, even though its results may be less spectacular. This would apply particularly to those industries where Australia's comparative advantage is less than obvious, and where the industry is threatened with excess capacity.

The Future

Since the mid-thirties, agricultural output in Australia has risen by one-half, with very little change in acreage and a fall of one-sixth in the agricultural work-force. Associated with this increase of three-quarters in output per man has been a considerable increase in capital requirements (particularly in the form of machinery), a growth in size and numbers of

the medium-size farm, and a decline in the importance of the very large properties.

In the medium-term future, I expect these trends to continue, but the pace of change will be considerably influenced by price levels for farm products and the availability of rural credit. With these qualifications, capital will continue to be substituted for labour, through mechanisation, in the process of farms becoming larger. On the other hand, in some areas capital will also substitute for land, through pasture improvement, and this may result in the subdivision of many large-medium farms. Larger capital requirements will probably result in more contract work by and for farmers, as a partial alternative to larger farms. The family farm will hold its place, but it will grow larger, in terms of output and probably in terms of acres.

In the long-term future, if we accept the "population bomb" hypothesis, the implicit rise in agricultural prices will result in a much more intensive agriculture. This would hasten the break-up of the large estates, but otherwise it need not involve a considerable reduction in farm acreage size. The intensification may take the form of more capital per acre (fertiliser, feed, machinery) rather than more labour per acre.

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THE AUSTRALIAN BROILER INDUSTRY

F. SKALLER

Introduction

Meat chickens, or Broilers in American terminology, are young chickens of either sex, tender-meated with flexible breastbone cartilage, and suitable for grilling, barbecueing, roasting, or frying.

The phenomenal development of the broiler industry, first in the U.S.A. and Canada, and more recently in most countries of western Europe, has changed chicken meat from a luxury food to a cheap, and sometimes the cheapest, source of meat to the consumer. Consumption of poultry in the U.S.A. has increased since the end of the war from 19 lb to 29 lb a head, of which approximately 80 per cent is contributed by broilers, compared with 14 per cent in 1940. Australia's present consumption has been estimated at 10 lb of poultry meat a head, of which 20 per cent is contributed by broilers (Skaller 1960).

Reasons for the Development of the Broiler Industry

The rapid development of the broiler industry was made possible mainly by the breeding of a special type of meat chicken with a feed conversion ratio high enough to allow the use of both sexes for meat production. Hence production is no longer dependent on the limited supply of crossbred day-old cockerels which are a by-product of the hatcheries producing pullets for the commercial egg farmer.

Any rapid increase in the production of red meat from cattle or sheep is limited by lack of suitable land, unfavourable climate, and the comparatively slow reproductive rate of ruminants. The rapid development of the broiler industry, however, is limited only by economic factors, in particular consumers' demand for chick meat at a price which still allows a profit margin, even though a very small one, to the producer.

Large numbers of day-old chicks can be produced within a very short time because pullets start laying before 6 months of age, because incubation takes only 3 weeks, and because hatcheries are becoming bigger. There are now several hatcheries in Australia producing half a million, and some producing over a million chicks a year.

Broilers are grown from day-old to marketing age in large sheds, almost independently of climate. All feed is purchased, usually from a stock-feed mill as a scientifically compounded ration. Management is in most cases highly efficient in the use of capital and labour. For example broilers are ready for killing and processing at 8-9 weeks in the U.S.A. and at 11-12 weeks in Australia, allowing a quick turnover of capital. Mass production methods are applicable with the result that one man can look after 40-60,000 broilers a year. The "all-in, all-out" system is normally practised thus reducing the spread of disease from one age group to another. It is not surprising therefore that the broiler industry has attracted capital and managerial skill from secondary industries and shows many features familiar to large scale production in those industries. Integration between hatcheries, stockfeed manufacturers, growers, and processors has marked the development of the American

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broiler industry and is now spreading to Australia. Unfortunately this forces many of the smaller producers out of business, but it increases the efficiency of the industry as a whole and allows reduction of costs and lower prices to the consumer.

Present Situation of the Industry

The Australian broiler industry differs from most other primary industries in that it has grown and is organised without the assistance of State Marketing Boards, without State subsidies or stabilisation schemes, and with little government assistance in the way of research.

The recent economic conditions, with restricted credit but unrestricted imports of canned poultry meat, increase in the volume of production but decrease in the consumers' purchasing power, have affected this young and expanding industry very harshly. Prices for 3-4 lb broilers have fallen from the satisfactory 1960 level of 2/10 to 2/4* per lb liveweight and less—in some cases below the production cost of even the more efficient grower.

An idea of the cost structure in the Aus-

*January to May 1961, 2/4 per lb; July to August 1961, 2/7 per lb.

TABLE 1

Cost structure of the Australian Broiler Industry at 2 Price Levels per lb Liveweight at 12 weeks of age, for 2 Types of Chicks.

Cost Item	Cost per Broiler (pence)		Cost per Broiler (expressed as percentage of return)			
			@ 2/9 per lb		@ 2/4 per lb	
	L × A (male)	Broiler (unsexed)	L × A (male)	Broiler (unsexed)	L × A (male)	Broiler (unsexed)
1 Day-old Chick:						
L × A cockerels, £5 per 100	12.0	....	11.76	....	13.82	...
Unsexed broilers, £8 per 100	....	19.2	....	18.18	....	21.43
2 Mortality at 4%	0.5	0.8	0.49	0.76	0.58	0.89
3 Feed cost at £45 per ton:						
Conversion rate 1 : 3.4 for 3.1 lb wt	55.1	....	54.01	....	63.48	...
Conversion rate 1 : 3.2 for 3.2 lb wt	....	55.3	....	52.36	....	61.73
4 Fuel	1.5	1.5	1.48	1.42	1.73	1.67
5 Litter — Cost balanced by sale of manure	..	..	.	..	.	..
6 Labour — one man at £20 for 10,000 birds	5.8	5.8	5.69	5.50	6.68	6.47
7 Depreciation — 10% Equipment, 5% Buildings	3.2	3.2	3.14	3.03	3.69	3.57
8 Interest, veterinary expenses, miscellaneous	2.0	2.0	1.96	1.89	2.30	2.23
9 TOTAL COST PER BIRD	80.1	87.8				
10 Return per bird at 2/9 per lb	102.0	105.6				
Profit (1960) per bird	21.9	17.8	21.47	16.86		
Profit for annual output of 40,000	£3,650	£2,966				
			100.00	100.00		
10 Return per bird at 2/4 per lb	86.8	89.6				
Profit (1961) per bird	6.7	1.8			7.72	2.01
Profit for annual output of 40,000	£1,116	£300				
					100.00	100.00

tralian broiler industry can be obtained from Tables 1 and 2. Good husbandry and efficiency in all operations have been assumed in constructing these tables. Unforeseen events such as outbreak of disease, effects of heatwaves, and so on will reduce or even eliminate the calculated profits.

TABLE 2

Comparative costs of broiler production in U.S.A. and Australia.

Cost Item	U.S.A. per lb liveweight	%	Australia per lb liveweight	%
	(cents)		(pence)	
Feed	15	60	17.3	64
Chick Cost	4	20	6.0	22
Labour	3	15	1.8	7
Miscellaneous	1	5	1.9	7
Total	23	100	27.0	100

Outlook

Although the present economic situation of the Australian broiler industry is most unsatisfactory, the long-term prospects are good. This optimistic outlook is based on the fact that the present consumption of broilers in Australia is only 2-3 lb a head, compared with 20 lb in the U.S.A. However, two conditions must be fulfilled if the industry is to prosper:

Firstly, the efficiency of all sections of the industry must continue to improve until overseas standards are reached. This will allow a gradual lowering of prices for the consumer without affecting adequate profits to the industry. This objective will have to be achieved mainly by breeding improved meat strains with better feed conversion rates.

Secondly, all sections of the broiler industry must combine in a publicity campaign to promote increased broiler consumption—a campaign directed particularly to the Australian housewife.

Breeding for Improved Broiler Strains

From the technical point of view, most efforts during the next decade will have to be devoted to the breeding of more efficient meat chicks and the formulation of better broiler rations. The problem is perhaps best stated by comparing present Australian standards with those in the U.S.A., where the development of a modern broiler industry started about 20 years ago. Approximately 2.5 lb of feed are required in the U.S.A. to produce 1 lb of live weight in a broiler reaching 3.5 lb at 9 weeks of age; in Australia, according to Random Sample Tests, at least 3.2 lb of feed are at present required to produce 1 lb of live weight in birds which reach 3.2 lb live weight at 12 weeks (Gulliford and Dallimore 1961).*

Although growth rate, which is closely associated with feed conversion, is the most important economic character to be improved by selection, there are other features which must not be neglected. Chick viability is another character important to the grower, egg production of the broiler's dam and hatchability are important to the hatcheryman; white plumage, white skin, high dressing yield and well fleshed shanks and breast are required by the processor and consumer. It is not easy to combine all these features in one breed. The broiler chicken is usually produced by crossing a male from a dominant white meat strain with especially good growth rate and conformation, to a dam combining growth rate with fitness characters and frequently a two-way cross herself.

These new meat breeds must be developed by the Australian breeder from the genetic material available in this country, as stringent and necessary veterinary regulations prohibit all imports from overseas.

Fortunately for the breeder, hereditability of growth rate is relatively high and therefore suitable for mass selection. It is also possible to produce 3 genetic generations in 2 years and to apply an extremely high selection pressure, as one sire can produce 12-15 male offspring, and a dam 1-2 daughters weekly. Finally, selection of the future parents can be carried out at the age of 11-12 weeks. This allows the yearly testing of large populations at economic costs and even progeny testing can be carried out without much loss of time.

*Most recent tests at some breeders' plants have shown considerably better results.

For example, at present, over 15,000 chickens are tested by the author each year at a commercial breeding farm. It has been estimated that under such conditions the growth rate of broilers to the age of 12 weeks can be improved by 0.25 lb per year, at least during the first years of a breeding programme.

About half a dozen breeders in Australia, including two commercial breeding companies employing their own geneticists, have embarked on a broiler breeding programme. This has been made economically feasible by the structure of the poultry industry, and in particular the broiler industry, which allows a few breeders to supply through a network of franchised hatcheries their "brand" of day-old chicks throughout the country, and even beyond, to the commercial growers of broilers. In the U.S.A., with an annual turnover of more than one and a half billion broilers, the position today is that nearly all the parents of these broilers come from less than half a dozen breeder-companies.

There are a few special problems the Australian broiler breeder has to cope with:

1. The potential market for day-old chicks, compared with the American market, is very limited because of Australia's relatively small population. Hence, the funds available for investment in a breeding programme, which have to come from the gross profits of sales of chicks, are comparatively small.
2. The most popular layer on Australian commercial egg farms is a crossbred pullet from a White Leghorn mated to an Australorp. The males of this cross can be and are being widely used for broiler production. Being a by-product, these cockerels, which otherwise would have to be destroyed immediately after sexing, can be bought very cheaply.

   Skaller (1960) has worked out tables at different chick price levels to show how much more efficient unsexed broiler chicks of a specialized meat strain must be to compete successfully with this by-product crossbred cockerel. It can be anticipated that in a few years special broiler strains will have improved so far that these by-product cockerels will be no longer used by the broiler grower, even if given away.
3. As pointed out before, the genetic material existing in Australia for the development of new broiler breeds is limited and there is no certainty that the available gene pool will allow the breeding of a meat chick as efficient as that already developed in the U.S.A. and the U.K.

Broiler Rations

As far as the *nutrition* of broilers is concerned we rely mainly on American practices and research findings. Little research work is done in Australia, though very valuable contributions have been made by Dr. McDonald at the N.S.W. Poultry Research Station, Seven Hills, who, at a recent symposium, stressed the importance of the following factors in formulating Australian broiler rations:

1. Availability of stable, fat soluble vitamin supplements.
2. The use of methionine and supplements with high vitamin level.
3. Reduction in salt levels in the diets and the use of potassium supplementation.
4. Reduction in available phosphorus levels by use of vegetable protein supplements.

More recently, the import of soyabean meal to replace part of the Australian meatmeals, at present being used as the main source of protein in broiler rations, has improved the nutrition of broilers. Although the formulation of American rations is well known to Australian nutritionists, many ingredients cannot be used economically in Australia. Most synthetic additives have to be imported and fat additives, such as tallow, are dearer here than in the U.S.A., where detergents have largely replaced soap and have created a surplus of tallow. Bartlett (1961) has shown at Werribee, Victoria, that supplemented rations, particularly if fed to special meat chick breeds, resulted in better feed conversion rates. They did not, however, significantly increase the profits to the broiler grower, as these rations were more expensive.

A particular problem in compounding efficient broiler rations in Australia is caused by lack of uniformity and low quality of many

Australian meatmeals. They frequently show deficiencies both in digestible protein content and in protein quality, in terms of balance of essential amino acids.

It is also possible that insufficient supplies of good quality meatmeals will retard the growth of the Australian broiler industry, unless the efforts now being made to establish an Australian Soyabean industry are successful.

Integration

Finally, capital for investment in broiler sheds, (approximately £3,000 including equipment for the growing of 25,000 broilers per annum) and processing plants must become more readily available at reasonable terms before the broiler industry can expand further. With diminishing profit margins, growers can only survive by large turn-over operation and high efficiency in all production factors, in particular, labour. This means that an efficient grower will have to turn out at least 10,000 broilers a run, which requires processors capable of handling such a volume efficiently within one or two days. Such large scale operations necessitate, if not integration, then at least close co-operation and long range planning between all sections of the industry, The hatcheryman has to plan his operations so that he can supply 10,000 and more chickens on a stipulated day to the grower; the grower must be certain that these 10,000 broilers will be cleared from his shed before the new batch of day-old chicks arrives; the processor has to organise a network of growers who will supply him regularly at pre-arranged dates with known quantities of broilers of standard quality and he must be able to market large volumes.

Much has still to be done in Australia to establish grading standards for poultry meat and standards of hygiene for killing and processing plants.

Distribution of Consumer's Shilling

Table 3 presents comparative data from the U.S.A. and Australia which demonstrates how all sections of the industry, and in particular the retailers, will have to reduce profit margins and costs before poultry meat can become a popular food served at least once a week by the Australian housewife.

TABLE 3

Distribution of price paid by consumer per lb broiler meat in U.S.A. and Australia to producer and marketing agencies at two price levels per lb liveweight.

	U.S.A.			Australia			
				@ 2/9 per lb*		@ 2/4 per lb*	
	per lb (cents)	%		per lb (pence)	%	per lb (pence)	%
Producer	24	59		49	54	42	51
Processor	7	17	22	17	19	17	21
Wholesaler	2	5					
Retailer	8	19		24	27	23	28
Consumer	41	100		90 7/6	100	82 6/10	100

*Liveweight prices of 2/9 and 2/4 per lb have been converted to prices per 1 lb dressed weight allowing for a processing loss of one-third.

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AMERICAN UPLAND COTTON; A POTENTIAL IRRIGATION CROP FOR SOUTHERN AUSTRALIA

A. L. C. DAVIDSON

In recent months an increasing degree of publicity has been given to the possibility of growing cotton in the irrigation districts of south-western N.S.W. and Victoria. Although some reports contain a measure of wishful thinking, a definite future is indicated for irrigated cotton in southern Australia.

The present note outlines the recent history of investigations with irrigated cotton south of Queensland, using both Egyptian and Upland varieties, and stresses the suitability of the region for Upland types only.

Introduction

Sporadic attempts to grow cotton in southern Australia have been made at intervals since the introduction of cotton to Queensland in the 1860s. In modern times, interest reached a significant level after the 1914-18 war, when there was a world shortage of cotton. In the early 1820s several successful trials were run, particularly by the South Australian Department of Agriculture at Berri (Quinn 1922).

Harding (1924) published a comprehensive survey of potential cotton growing regions in Australia, mentioning the need for irrigation in certain districts. With only minor adjustments to suit the changed conditions of today, Harding's work can still be taken as an authoritative guide to Australia's potential for cotton production. However, until fairly recently his recommendations have aroused little interest outside Queensland.

After 1926, world supplies of cotton were plentiful and Australian interest in the crop lapsed except in Queensland, where cotton was used as a pioneer crop in clearing Brigalow scrub.

In the ensuing thirty years an idea gained ground that the climate of southern Australia was too cold for cotton to be successful, in spite of occasional trials which showed the contrary. This possibility arose from the fact that in the later trials of the 1920s only Egyptian or similar varieties were used. They require a seven-month growing season as against five months for American Upland, which is the type normally used by Australian spinners. The hypothesis ignores the fact that both in the U.S.A. and Europe, cotton is consistently grown in climates less favourable than that of the central Murray Valley.

Recent Developments

Since about 1955 there has been a revival of interest in cotton in several directions. In the exceptionally wet season 1955/56 a successful set of trials was laid down at Tullakool, N.S.W., under the auspices of the Department of Agriculture. This was followed by the establishment in 1958 of the Department of Agriculture Research Farm at Narrabri in the north-west of the State, with a view to testing the prospects for cotton supplied with water from the Keepit Dam. Some private trials by farmers in the Murrumbidgee Irrigation Area and Murray Valley around that time were also successful.

In 1955 during a stay in the United States, the writer formed the opinion that the soils

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and climate of the Murray Valley and Lower Darling would be well suited to cotton. Also in that year Mr. F. Penman, then Officer-in-Charge of C.S.I.R.O. Commonwealth Research Station at Merbein, Victoria, had inspected cotton under irrigation in Russia and come to the same conclusion.

Arising from discussions between us, a series of co-operative trials was instituted at Merbein and later extended to farms within a radius of fifty miles of the Station. In the first instance, a comprehensive review was made of local climatic and soil conditions, followed by a more detailed study of the crop in Queensland and the U.S.A. (Mr. A. V. Lyon, Mr. Penman's predecessor at Merbein, provided useful information regarding trials at that Station in the 1920s using Egyptian varieties.)

The first plantings were made at Merbein in 1957/58. The trial had a double objective; firstly to introduce up-to-date varieties suitable for irrigation, and secondly to study their behaviour under local conditions. Although planted very late, the trials showed good promise and were extended the following season.

From that time there has been a steady awakening of interest in irrigated cotton. Some 40 plantings are known to have been made in the Murray-Murrumbidgee Irrigation Districts, ranging from garden plots to commercial acreage. As well as the C.S.I.R.O. Research Stations at Merbein and Griffith, the N.S.W. Department of Agriculture has run trials on its Experiment Farms at Yanco and Leeton and given active support to the investigations from its centres at Dareton and Barham and in the Murrumbidgee Irrigation Area. During 1960/61 cotton was grown commercially near Forbes, N.S.W., with marked success.

From these plantings a clear pattern is emerging. For the present, progress may be summarized as follows:

1. American Upland cotton of a quality comparable with world standards can be brought to full maturity in a large section of southern Australia.
2. Climatic conditions should be suitable for most Upland varieties north and west of a line drawn through Renmark, Wentworth, Gunbar, Condobolin and Boggabri to Brisbane.
3. Selected varieties will be successful in a transition zone bounded roughly by the Sturt Highway in South Australia, the Murray Valley Highway in Victoria and the Newell Highway in N.S.W.
4. Certain districts flanking these limits, for example Berrigan and Yarrawonga, may prove suitable, but they will need a series of careful trials to establish the limits of operation. Into this category must also be placed for the present the Coleambally Irrigation Area and most of the Murrumbidgee Irrigation Area—the latter mainly because of the erratic incidence of frost.
5. A further criterion in considering a district for cotton is that it should have an average frost free period of 210 days or more, and an annual evaporation of 55 inches or more. (60 inches for safe areas.) The frost-free period is longer than the 190 days accepted in the U.S.A. because midsummer temperatures are usually lower in N.S.W.
6. Two problems of management are of prime importance, namely obtaining a good initial stand of plants and controlling weeds. Even the best American techniques are helpful only up to a point. Our soils are more diverse than in U.S.A. and weed infestation is generally more severe. So far, other than on some exceptionally favoured farms, it has not been possible to dispense with hand labour for weeding. This problem should be overcome in time, but meanwhile it is a limiting factor for several otherwise promising districts where casual labour is scarce.
7. The idea that areas suitable for cotton growing can be defined on the basis of temperature alone is a fallacy. The saturation deficit or "evaporative power" of the air, and the rate of removal of air containing transpired water, play an important and perhaps dominant role in determining the rate of development of cotton, i.e. number of nodes as distinct from size of plant. Within reasonable

limits, when considering the prospects of any site for growing cotton, evaporation is a better guide than temperature. A relation between evaporation and productivity of grasses in Queensland has been noted by Williams (1959). However, temperatures above 58°F are required for active growth.

8. In line with this evaporation factor, high wind régimes, which are common in the Riverina, favour faster growth rates than might be expected from consideration of temperature alone. An extreme case of this occurs in Perth, W.A., where C.S.I.R.O. Plant Introduction Station at Kelmscott successfully matured two newly-introduced varieties in successive years. By contrast, the presence of irrigation on an extensive scale as in the Murrumbidgee Irrigation Area may cause a local rise in humidity and a consequent slowing of growth.
9. Cotton is very sensitive to management practices. A proper assessment of its water requirement is essential. This will differ from soil to soil and from district to district. The water relations of cotton should provide a fruitful field for research if the crop is to develop on a large scale. Bad management can both reduce the yield of the crop and retard its maturity by some weeks. The latter may mean the difference between success and failure in marginal areas.
10. Yields so far obtained under prudent management have been highly encouraging. In several places yields of over 3,000 lb per acre of seed cotton have been obtained, both in trials and on a commercial scale. (Similar results have been recorded under partial irrigation at Narrabri by N.S.W. Department of Agriculture). For cotton to be seriously considered as a permanent irrigation crop, yields of 2,000 lb per acre upwards are necessary.
11. Fertilizer requirements are roughly in line with U.S. experience. Local trials will be required in order to determine optimum levels. Cotton has proved tolerant of soil chloride of the order of 1,000 p.p.m. chlorine.
12. In general, cotton should not be planted after mid-November in southern N.S.W. and Victoria if payable yields are sought. The earliest planting date varies according to districts, but is approximately mid-October.
13. Shelter from cold south-westerly winds in spring is a distinct advantage. Exposure to hot northerlies appears to be unimportant.

Economic Prospects

So far, all plantings which have been managed within the limits defined by established American practice have been successful. Similar success can be expected in future; some areas will need to guard against summer flooding. The few partial failures which have occurred could clearly be attributed to one or other of the following causes:

Planting unreasonably late.
Planting a late-maturing variety.
Inadequate weed control.
Loss of early crop through insect damage or shortage of water or nutrients.
Mismanagement of watering, deliberate or otherwise.
Failing to replant thin stands.

In effect, cotton is not a crop which can be left to its own devices or treated as a sideline. It demands skill and conscientious management and accurate timing of operations. Given proper attention it can turn out to be the most rewarding of any field crop in terms of net cash income per man-hour or per acre-foot of water. Efficient management is difficult without special row-crop equipment including a high-clearance tractor. These items are expensive, and lack of finance has deterred many farmers from growing cotton.

It is not the province of this paper to discuss the pros and cons of the Bounty Act by which the Commonwealth Government encourages cotton growing in Australia. Suffice it to say that a yield of 3,000 lb per acre exceeds the average of Arizona and California, the highest producing States of the U.S.A.

In the next few years, we may expect significant developments from hybrid production. Yields may be greatly increased with a corres-

ponding reduction in the cost of production. In this connection the recent work of Derera at Narrabri holds out great promise for the future. Along with this development may come new types of cotton adapted to a wider range of climatic conditions.

Broadly speaking, therefore, there is good reason why the growing of cotton in southern Irrigation Districts should be encouraged. Much of N.S.W. is clearly safe for production of American Upland varieties. For the more marginal areas, it is hoped to present later a quantitative analysis of the behaviour and prospects of cotton under varying climatic conditions. However, this must await the collation of further data including the results of season 1960/61.

General Observations

i. There is scope for developing irrigated cotton as an industry in southern Australia. Suitable conditions exist along the Murray River for a considerable distance upstream from Blanchetown, S.A. Parts of the Perth Coastal Plain are also suitable, but there are marketing difficulties in W.A.

ii. Cotton produced in trials to date has been of the highest quality. No difficulty has been experienced in maturing a crop, even in adverse seasons, provided planting is done at the right time with the right variety and the crop is conscientiously managed.

iii. The economics of cotton appear to be attractive. Basically it can be more profitable per acre than rice, while using only half the amount of water. Production costs are high and a rather heavy outlay on row-crop equipment is necessary; present development is being hampered by shortage of credit to farmers. The market for quality cotton is good, since Australia currently imports about 90 per cent of its raw cotton requirements.

iv. Encouragement of row crops like cotton should lead to a better seasonal distribution of water requirements in irrigation districts. Returns from cotton can be so much greater than from pastures that the crop merits a degree of priority in times of water scarcity. Autumn watering is not required for cotton.

v. There is much to be learnt concerning the water requirements of cotton as regards both quantity and timing in various soils. Cotton would be an ideal subject for a research project on water relations —a project which should also yield information useful in the management of other field crops. However, development can safely proceed on the basis of present knowledge.

vi. At present and for some time to come it will be necessary to experiment with several varieties in order to select those most suitable to a given district. Ultimately it should be aimed to confine a district to one or two varieties only, in order to maintain quality.

vii. Both the length of growing season and the need for hand harvesting preclude growing Egyptian-type (long-staple) cotton. Also there is virtually no market for this type in Australia. Production should be confined to Upland varieties.

viii. Experience will enable the problems of germination and weed control to be overcome. If this is done there is no reason why southern Australia should not develop a flourishing cotton industry.

Acknowledgments

The progress of experimentation in southern districts has been greatly advanced by the help and encouragement of Government bodies and individual farmers. Much valuable information and assistance has been given by officers of the Queensland Department of Agriculture and Stock and the Cotton Marketing Board; N.S.W. Department of Agriculture and Water Conservation and Irrigation Commission; C.S.I.R.O. Division of Soils, Adelaide; Division of Plant Industry at Canberra and Perth; Division of Land Research and Regional Survey, Canberra; and the Commonwealth Department of Health, Canberra. Messrs. Davies Coop Ltd., Melbourne, have given ready assistance with laboratory tests of fibres.

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Letters

Effect of Time of Planting on Yields of Safflower in Northern Australia

Introduction

In 1956 and 1957 two time-of-planting trials with safflower grown as an irrigated winter crop were carried out at the Kimberley Research Station (15°7'S lat.; 128°7'E long.). The main objective of these trials was to ascertain the effect of planting date on yields. However, since little is known about safflower other results recorded are of some interest.

The trials were carried out on alkaline heavy clay soil. During the experiment, temperatures and humidity did not depart significantly from the average figures (Table 1).

Agronomic techniques and dates of planting were almost identical in both trials. The first planting was made on May 3, 1956 and a day earlier in 1957. Subsequent plantings were carried out at fortnightly intervals until the eighth planting on August 9, 1956 and the ninth planting on August 23, 1957.

In both trials the crop was planted on ridges 33inches apart and furrow irrigated at intervals of 10 to 14 days. It received 3 cwt per acre of superphosphate, and 1 cwt per acre of ammonium sulphate. The variety, 48-89-B, used in both trials is one of the selections made by Horowitz at the Waite Institute from bulk material of Egyptian origin.

Results and Discussion

The data in Figure 1(A) show progressive yield decline with later planting. In 1956 the decline began with crops planted after mid-June; in 1957 it began with crops planted after mid-May. This difference cannot be explained on the basis of available records.

In 1956, when plant population at harvest was recorded (Figure 1B), there was no significant correlation between plant numbers and yield irrespective of the time of planting. However, correlation between plant population and yield for each individual treatment was significant ($r = 0.737$) implying that time of planting influenced yields largely through plant population. Since the plant population at harvest is at least partially determined by such controllable factors as initial establishment, pest damage and weed competition, it remains to be ascertained whether the reduction in plant numbers in the later plantings is due to these controllable factors on whether it is the inevitable outcome of seasonal changes in environment.

TABLE 1

Rainfall and Temperatures in the 1956 and 1957 Safflower-Growing Season compared with Averages.

	Mean Minimum Temperature (°F)			Mean Maximum Temperature (°F)			Rainfall (in.)		
	1956	1957	Average	1956	1957	Average	1956	1957	Average
May	66.6	60.2	63.5	91.3	90.8	91.8	3.74	—	0.25
June	61.2	64.4	60.8	87.2	88.4	87.1	—	3.41	0.22
July	61.2	59.0	58.0	87.8	84.4	87.3	2.56	—	0.12
August	60.1	56.6	59.5	89.2	90.6	91.0	—	—	0.03
September	69.1	61.0	64.8	94.7	96.6	96.3	—	—	0.10
October	71.5	74.4	72.6	102.7	101.5	101.5	0.43	0.64	0.78
November	76.5	76.4	76.2	103.7	103.3	102.1	1.28	1.37	2.72

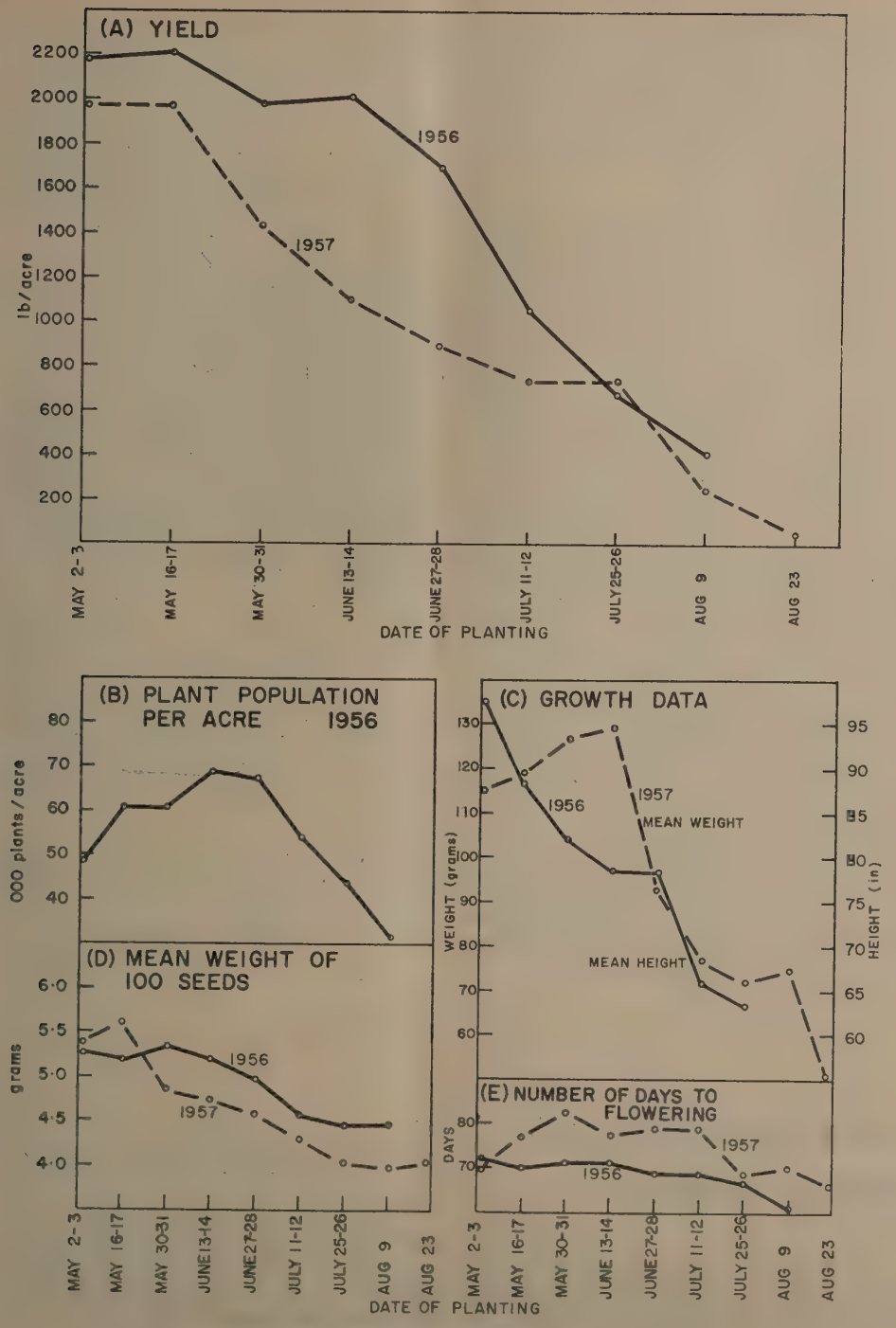

Figure 1—Effect of time of planting on yields of safflower.

It is of interest that in 1956, in the first planting with stand reduced by waterlogging, the lower plant population was largely compensated for by an increased mean number of heads per plant. There was no such compensatory effect with the late plantings which had even lower plant numbers.

The decline in yield was also associated with lower weight (1956 trial) and height (1957 trial) of mature plants (Figure 1C). The measurements carried out in 1957 indicated that the reduction in final height was due to slower early growth and shorter period of elongation. The maximum rate of elongation was the same in all plantings.

Finally, the decline in yield was associated with lower mean weight of individual seed (Figure 1D) ($r = 0.855$ in 1956 and $r = 0.969$ in 1957). The date of planting had no apparent effect on percentage of kernels in the whole seed, which varied from 48 to 53 per cent in 1956 and 45 to 57 per cent in 1957.

Oil content of seed ranged from 27.4 to 31.7 per cent in 1956 and from 19.3 to 30.1 per cent in 1957. There was a tendency to lower oil content in late planted crops. There was also a tendency to lower iodine value in late planted crops. This was specially evident in the 1957 trial when iodine value steadily declined from 146 to 136, from the first to the ninth planting.

The time from emergence to commencement of flowering (Figure 1E) varied from 72 to 61 days in 1956, and from 84 to 65 days in 1957. There was a tendency for late planted crops to flower more quickly, but in 1957 the first planting flowered more quickly than those of late May and June.

The practical implications of the results quoted are clear. It is desirable to plant safflower before the end of May to obtain maximum yields. Early planting is also advisable since it reduces the risk of harvest damage by the following early rains. Finally, late planting may also be responsible for lower oil content and iodine value. However, the time taken by the existing methods of land preparation and weed control makes early planting difficult in years when the rainy season finishes late. Experimental work is under way to tackle this problem.

Little physiological research has been done on safflower and the reasons for the behaviour of the crop are not clear. In the Kimberley region the increase in day length is closely associated with a rise in temperature, and thus photoperiodic and thermal responses cannot be separated.

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Training Agricultural Scientists
Where are we going?

The problems of training undergraduate and graduate students are constantly under review at the Melbourne School of Agriculture. The basic consideration, of course, is that the training given should produce men and women with the sound educational background required in the careers available to them.

To obtain an over-all picture of career opportunities the first placement in employment of the graduates from the Melbourne School over the five-year period 1956 to 1960 has been determined. The figures are presented in Table 1.

TABLE 1

	1956	1957	1958	1959	1960	Total	%
Dept. of Agric., Victoria	6	13	7	14	12	52	30.8
Other Departments	6	7	12	5	9	39	23.1
Universities	3	3	6	7	12	31	18.3
Education Departments	0	5	5	5	2	17	10.0
Industry	1	4	2	3	4	14	8.3
Farming	1	—	3	2	2	8	4.8
Married, etc.	2	2	2	1	1	8	4.8
	19	34	37	37	42	169	

Reference to Table 1 shows that some 30 per cent of the total graduates found employment with the Victorian Department of Agriculture and that 23 per cent joined other government departments. These departments include the Tasmanian Department of Agriculture, C.S.I.R.O., the State Rivers and Water Supply Commission, the Soil Conservation Authority, the Fisheries and Wildlife Department, the Melbourne and Metropolitan Board of Works, the Commonwealth Department of Territories and the New South Wales Department of Agriculture. Some 10 per cent of graduates are teachers with the Education Departments of Victoria and Tasmania. This means that almost two-thirds of the total number of graduates produced have chosen careers in public service.

It is of interest to note (Table 1) that increasing numbers of students have returned to the universities for post-graduate training. This is a direct response to the demand for more highly trained and specialised people in research organisations.

The demand for graduates in industry is not being met although one in twelve elected to work in this field. One or two graduates each year have chosen farming as a career and a similar number (females) have married and have retired from the profession. Seventeen (10 per cent) of the graduates were females.

The graduates engaged in the professional field (152) have been categorised according to the fields of agriculture in which they are employed. The results are presented in Table 2.

The figures show that almost half the total number of graduates are working with soils or plants and 27 per cent with livestock. The remainder (24 per cent) are school teachers or are working in specialised scientific fields.

An attempt has been made to classify graduates professionally employed (152) according to the emphasis of the work within the categories listed in Table 2. The result is presented in Table 3.

Reference to Table 3 indicates that more than half the total number of graduates produced in the five-year period are engaged in research, the remainder in extension work or teaching. However, it has not been possible

TABLE 2

Employment expressed as percentage of graduates in year.

	1956	1957	1958	1959	1960	Total
Agronomy, Horticulture	31	44	50	38	58	46
Livestock	50	25	16	27	29	27
Education	—	16	22	27	5	15
Soils	13	3	6	—	—	3
Miscellaneous*	6	12	6	8	8	9

*Bacteriology, Biochemistry, Entomology, Economics.

TABLE 3

Employment expressed as percentage of graduates in year.

	1956	1957	1958	1959	1960	Total
Research	57	45	59	53	58	54
Extension	43	39	22	24	37	32
Teaching	—	16	19	24	5	14

to differentiate between workers concerned exclusively with research and those undertaking research on a part-time basis. Consequently the category "extension" has been restricted to workers with purely advisory and administrative functions. Many of the "research" category are responsible for some work in the extension field.

The problem of training students in the numbers required to meet the demand for graduates is constantly under review. It has not proved possible to assess the potential demand for trained people but the evidence available suggests that the requirement is for at least 50 per cent greater output than at present. Employing authorities generally endorse the policy of the Melbourne University School of Agriculture in producing graduates with a broad general training in the basic principles of agriculture. The development of a strong graduate school is aimed at the production of more highly specialised people for employment in the research and extension fields and in industry.

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Frenching in Nicotiana Species

Frenching is a physiological disorder of tobacco and allied species manifest at first by reticular chlorosis, which is followed later by a strap-leaf condition. Kefford (1959) showed that these distinctive symptoms were associated with a deficiency of auxin within the plant.

Steinberg (1960) reported that fifty-five of the fifty-seven species of *Nicotiana* he had tested proved susceptible to frenching, although Wolf (1935) and Spencer (1935) had each listed a number of species as resistant. Steinberg distinguished between three types of symptoms, the susceptible species producing strapleaves, small leaves, or transient reticular chlorosis. The two species he found resistant to frenching were *N. acaulis* Speg. and *N. thyrsiflora* (Bitt.), both being winter hardy perennials.

Over the past five years, as new seed lines of *Nicotiana* species have been received at Canberra, they have been screened for resistance to frenching in the greenhouse. Plants have been grown in pots of soil from Katherine, Northern Territory, because this soil was known to produce severe frenching of tobacco. It was hoped this screening would reveal resistance or tolerance to frenching that could be introduced into tobacco by plant breeding methods.

Up to the present time seed lines of fifty-eight recognized *Nicotiana* species have been

TABLE 1

Frenching in Nicotiana *Species.*

Species	Number of Lines Tested	Minimum time for Frenching (Days)
Subgenus Rustica		
N. glauca Grah.	31	15
N. paniculata L.	3	9
N. knightiana Goodsp.	2	36
N. solanifolia Walp.	1	18
N. benavidesii Goodsp.	1	7
N. cordifolia Philippi	2	13
N. raimondii Macbride	1	17
N. rustica L.	24	11
Subgenus Tabacum		
N. tomentosa Ruiz et Pav.	2	8
N. tomentosiformis Goodsp.	1	12
N. otophora Griseb.	1	9
N. setchelli Goodsp.	1	11
N. glutinosa L.	2	8
N. tabacum L.	300	5
Subgenus Petuniodes		
N. undulata Ruiz et Pav.	2	12
N. arentsii Goodsp.	1	10
N. trigonophylla Dunal	2	13
N. palmeri Gray	1	8
N. sylvestris Speg. et Comes	3	11
N. langsdorfii Weinm.	1	8
N. alata Link et Otto	2	9
N. forgetiana Hort ex Hemsley	2	9
N. bonariensis Lehm.	1	14
N. longiflora Cav.	8	13
N. plumbaginifolia Viv.	5	12
N. repanda Willd. ex Lehm.	1	8
N. stocktonii Brand.	1	16
N. noctiflora Hooker	1	10
N. petuniodes (Griseb) Millan	1	15
N. acuminata (Grah.) Hooker	2	10

Species	Number of Lines Tested	Minimum time for Frenching (Days)
Subgenus Petuniodes		
N. pauciflora Remy	1	23
N. attenuata (Torrey) Wats.	1	11
N. miersii Remy	2	28
N. corymbosa Remy	1	21
N. linearis Philippi	1	14
N. bigelovii (Torrey) Wats.	2	8
N. clevelandii Gray	2	14
N. nudicaulis Wats.	2	8
N. benthamiana Domin	7	11
N. umbratica N. T. Burbidge	7	16
N. cavicola N. T. Burbidge	11	12
N. debneyi Domin	10	13
N. gossei Domin	18	12
N. amplexicaulis N. T. Burbidge	4	21
N. maritima Wheeler	4	18
N. velutina Wheeler	43	10
N. hesperis N. T. Burbidge	2	20
N. occidentalis Wheeler	26	8
N. simulans N. T. Burbidge	30	18
N. megalosiphon Heurck, et Muell.	42	8
N. rotundifolia Lindley	16	13
N. excelsior J. M. Black	10	16
N. suaveolens Lehm.	17	12
N. ingulba J. M. Black	7	8
N. exigua Wheeler	13	14
N. goodspeedii Wheeler	9	36
N. rosulata Domin	14	11
N. fragrans Hooker	1	22
Horticultural Forms and Amphiploids named as species.		
N. X *sanderae* Hort. ex Wats.	1	10
"N. diglauca"	1	22
"N. digluta"	1	11
"N. dirugla"	1	13

Figure 1.—A plant of Nicotiana glauca Grah. showing older leaves of normal shape which were produced before transplanting, and clusters of strapleaves which were produced after the plant was transferred to a frenching soil.

tested and all these species have, in time, produced typical strapleaf symptoms (Figure 1). The two species recorded as non-frenching by Steinberg have not been available for testing at Canberra. One horticultural form and three amphiploids that have been given specific names have also been tested and found susceptible to frenching. The numbers of samples from different sources tested and the minimum period for the development of frenching symptoms (reticular chlorosis) are shown for each species in Table 1.

The species are listed in the order in which they are described in the monograph by Goodspeed (1954) except for the section Suaveolentes in which the order is that followed by Burbidge (1960).

The frenching factor in the Katherine soil under the conditions of the Canberra greenhouses appears to be stronger than that in the soil used by Steinberg as the times required for frenching symptoms to develop were, in general, shorter in the Canberra screening than those obtained for the same species by Steinberg. All species developed strapleaves in the Canberra screening, whereas in Steinberg's tests some species gave only a transient reticular chlorosis and others small leaf symptoms. Although some species of *Nicotiana* take longer than others to develop frenching symptoms none of those tested at Canberra has sufficient tolerance to indicate that *N. tabacum* could be made appreciably more tolerant to frenching by the introduction of genes from any of these species. The resistance of *N. acaulis* and *N. thyrsiflora,* the two species found resistant by Steinberg should be confirmed under other conditions before it can be recommended for use in breeding tobacco varieties suitable for growing on frenching soils.

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Theses on which higher Degrees were Awarded in The Faculties of Agriculture of Australian Universities – 1960

University of Adelaide

M.Ag.Sc.	P. R. Birks	Polymorphism in aphids with particular reference to the influence of the host plant on the development of alate and apterous forms in *Aphis craccivora* Koch. (Homoptera: Aphididae).
M.Ag.Sc.	W. J. Lovett	Leaf problems in the production of Australian tobacco and its relationship to potassium nutrition.
M.Ag.Sc.	R. J. van Velsen	Investigation of Centrosema mosaic; a hitherto undescribed virus of Crotalaria. spp. in Papua and New Guinea.

University of Melbourne

Ph.D.	I. D. Wardrop	The physical and functional development of the forestomachs of the lamb.
M.Agr.Sc.	J. E. Vercoe	The grazing intake of sheep and related measurements.

University of Queensland

Ph.D.	B. N. Richards	Soil fertility and nutrition of Pinus.
M.Agr.Sc.	W. Arndt	Plant and soil reactions to a decade of continuous peanut cropping on Tippera sandy clay at Katherine, N.T.
M.Agr.Sc.	F. H. Kleinschmidt	The influence of grazing and nitrogen on the botanical composition of an irrigated pasture at Lawes.

University of Sydney

Ph.D.	M. W. McDonald	Heterosis: a study of associated genetic and biochemical factors in poultry and its use in improving commercially important characters.
M.Sc.Agr.	D. Reilly	The epidemiology and control of "dollar spot" diseases on turf in the Sydney metropolitan area.
M.Sc.Agr.	P. M. Martin	Competition between pasture plants with special reference to seed size effects and the interactions of competition for light and for nutrients.

M.Sc.Agr.	H. M. Churchward	Complex soil groundsurface development in an aeolian landscape: a study of soils near Swan Hill.

University of Western Australia

Ph.D.	M. J. Mulcahy	The soils of the York-Quairading Areas, Western Australia.
Ph.D.	J. J. Yates	Seed-setting in subterranean clover.
Ph.D.	R. T. Lange	The occurrence, characteristics and classification of Rhizobium associated with indigenous Leguminosae in South-Western Australia.
M.Sc.(Agric.)	E. Bettenay	Pedology of the soils in the Merredin Area, W.A., with particular reference to erosional and depositional surfaces and their effect on soil genesis and distribution.

Thesis Summary

Complex Soil and Groundsuface Development in an Aeolian Landscape: a Study of Soils near Swan Hill.

The inter-relationships of diverse soil materials in the dune-swale formations of the Swan Hill (Vic.) district show that, though some of this diversification is pedogenic in nature, much of it may be related to a sequence of independent soil layers or groundsurfaces.

The basis for distinguishing inter-layer and intra-layer variation is discussed. It is shown that the latter has an interdependence corresponding to an eluvial-illuvial relationship, whilst the former shows a discordant and even random relationship. Some understanding of layer genesis is sought by granulometric examination. The layers comprise a dust, or suspension component and a saltation, or dune sand component. These materials appear to be the result of wind erosion of the soils of a previous groundsurface, a process which seems to have led to the ablation and sorting of components. The suspension fraction is thus separated from the saltation sand and comprises clay, lime and a companion sand (less than 200 microns diameter): this is parna. Under conditions of accession to a site when saltation sand is in motion it would seem that parna becomes mixed with the saltation sand.

Evidence suggests a periodic moulding of the dunes by local erosion and deposition and accession of regional parna under the predominant influence of northerly and westerly winds.

Trends in soil development indicate an initial general homogenization by biotic agencies followed by non-biotic organization leading to the development of the characteristic features of fabric, consistence, and structure.

It is considered that a vertical sequence of soil layers is an indication of periodic landscape development, a phenomenon which has involved several periods of erosion, deposition,

and burial, each separated by periods of soil formation. A chronological statement on the development of these groundsurfaces is presented. It seems that the alternation of climate from arid to more humid, with its consequent effect on vegetation was of prime importance in affecting the periodic development of groundsurfaces at Swan Hill. The magnitude of both the stable and unstable phases shows waning trends from the earlier to the most recent groundsurface.

This study indicates that certain genetic anomalies, particularly with regard to Solonized Brown or Mallee soils, may be explained in terms of multiplicity of soil systems.

H. M. CHURCHWARD.

Awarded the degree M.Sc.Agr. by the University of Sydney.

Soil Fertility Studies on the Coastal Lowlands of Subtropical Queensland in relation to the Nutrition of *Pinus*

The fertility status of a sandy podzolic soil from the coastal lowlands of subtropical Queensland was measured in pot cultures and field trials by the responses of *Pinus taeda* L. and *P. caribaea* Mor. to added nutrients. Deficiencies of both phosphorus and nitrogen restrict the growth of *Pinus* in this soil. No response to nitrogen can be expected until the phosphorus status of the soil is improved, and the response to phosphorus increases when the nitrogen deficiency is corrected.

In the field there is an interaction between cultivation and phosphorus which is thought to be another expression of the nitrogen x phosphorus interaction. *P. taeda* responds to added phosphorus only when blady grass (*Imperata cylindrica* (L.) Beauv. var. major (Nees) C. E. Hubbard) is destroyed by cultivating the site before planting. Cultivation is considered to increase the supply of available nitrogen to the pines by removing competition from blady grass and/or promoting mineralization of organic nitrogen.

High levels of available nitrogen in the soil depressed germination, survival and early growth of *Pinus,* nitrate being more effective than ammonium nitrogen. A plentiful supply of available nitrogen at sowing appears to increase the susceptibility of pines to attack by soil-inhabiting pathogenic fungi, causing pre-emergence killing and damping-off. There was no evidence of a nitrogen x phosphorus interaction at this stage of growth, but there was a pronounced nitrogen x calcium interaction caused by the fact that heavy dressings of calcium carbonate promoted nitrification of the ammonium ion, resulting in heavy damage to germinating seedlings. Lime-induced chlorosis occurred in two pot experiments and was overcome by adding iron as Fe EDTA.

P. taeda responded to magnesium in two pot experiments, but the conditions under which magnesium deficiency occurs have not yet been clearly defined. There is evidence that interactions among the macronutrient cations are important in determining the growth rate of pines in this soil.

The effect of nutrient supply on mycorrhiza development was studied by comparing the relative number of mycorrhizal short roots on seedlings grown with or without added nutrients. Over the range of pH values 5.5 to 7.5, mycorrhiza development is not affected by soil reaction *per se*. Mycorrhizas will develop in neutral or slightly alkaline soils provided soil nitrate levels are low. This has not previously been recognized, presumably because nitrification is a common process in such soils.

Mycorrhiza development declined as the total nitrogen content of seedling roots increased. A test was made of Bjorkman's hypothesis that the formation of mycorrhizas is conditioned by the presence of surplus

soluble carbohydrate in the root tissues. It was found that mycorrhiza per cent in *P. caribaea* could be correlated with the soluble carbohydrate/total nitrogen ratio but not with the level of soluble carbohydrate alone.

B. N. RICHARDS

Awarded the degree Ph.D. by the University of Queensland.

The Influence of Grazing and Nitrogen on the Botanical Composition of an Irrigated Pasture at Lowes

A grazing experiment in which grazing was at six-weekly and eight-weekly intervals, and six-weekly with two mid-summer grazings omitted was conducted on a mixed pasture of H.1 rye grass, *Phalaris tuberosa* and white clover.

H.1 rye grass contributed very little to the yield of the pasture after its first flush of growth following planting. At the end of the experiment, H.1 rye grass in the six-weekly grazed treatment was contributing 7 per cent of the total yield, in the eight-weekly treatment, 1.2 per cent, and in the spelled treatment, 0.2 per cent.

Resting for the period of four months during mid-summer favoured development of *Phalaris*. At the end of the experiment, *Phalaris* in the spelled treatment was contributing 50 per cent of the total yield, whilst in the six-weekly and eight-weekly grazed treatments, *Phalaris* was contributing only 22 and 29 per cent respectively. Resting also reduced clover dominance.

A nitrogen fertilizer trial was also conducted. Nitrogen dressings were split and varied from 0-277 lb of nitrogen per acre. Nitrogen increased yield of the pasture in early stages whilst H.1 rye grass was the dominant species. Subsequently nitrogen had little effect on total yield. It increased the quantity of grass in the mixture.

F. H. KLEINSCHMIDT

Awarded the degree M.Agr.Sc. by the University of Queensland.

Competition between Pasture Plants, with Special Reference to Seed Size Effects and the Interaction of Competition for Light and for Nutrients

This thesis contains the results of an investigation of competition between *Lolium multiflorum* Lam. and *Phalaris tuberosa* L. in the seedling and early growth stages.

The basic autecological data such as growth pattern, net assimilation rates, response to various levels of nutrient and transpiration rates are recorded in Section I. This work showed that *L. multiflorum* had a higher relative growth rate than *P. tuberosa* in the early stages, but this difference gradually disappeared, and in the established sward both show similar net assimilation rates. In general, *Phalaris* was more sensitive to lowered nutrient level than *L. multiflorum*, and also showed a higher transpiration rate.

The more rapid early growth of *L. multiflorum* is doubtless the key to its success over *Phalaris* in competition, and although the relative growth rate is higher there is also the possibility that the larger seed size may even further increase its advantage.

The effects of seed size and depth of planting are examined in Section II. A highly significant correlation was found to exist between seed size and seedling vigour. At a

later date the correlation was not so close (though still significant), owing to mutual shading reducing the relative growth rate of the larger species, and thus allowing the smaller species to outgrow the difference to some extent. Experiments with pure dense stands of various Lolium species grown from different sized seeds showed that when the Leaf Area Index was high, seed size had no effect on final yield, but when the leaf area index was low, stands from large seeds considerably outyielded those from small seeds.

Varying depth of planting with *P. tuberosa* and *L. rigidum* Gaud showed that as depth of planting increased percentage emergence decreased to a highly significant degree. In both species there were no differences in yield of tops at approximately six weeks from planting, but increased depth of planting had the effect of reducing the root weights.

When large and small seeds of the one species were planted together, the plants derived from the small seeds were suppressed to a very marked degree by the plants derived from the large seeds.

Section III consists of a series of experiments on the interaction of factors in competition. Although the concept was first proposed by Clements (1905) the first experimental demonstration of such an effect was that of Donald (1958), who found that competition for light and for nutrients interacted. The present experiments demonstrate such interactions for a wide range of nutrients and light, thus providing additional confirmation of the Clements concept.

In general, the higher relative growth rate and larger seed size of *L. multiflorum* give it the initial advantage over *Phalaris,* and this, followed by the interaction of competition for light and for nutrients results in a very effective suppression of *Phalaris tuberosa.*

P. M. MARTIN.

Awarded the degree M.Sc.Agr. by the University of Sydney.

The Epidemiology and Control of "Dollar Spot" Disease on Turf in the Sydney Metropolitan Area

The fungus *Sclerotinia homoeocarpa* F. T. Bennett causing "dollar spot" disease on *Agrostis tenuis* Sibth Bent grass greens in the Sydney metropolitan area is a non-sporing type. The disease can be particularly severe in the coastal areas of Sydney when the environmental conditions favour its development, and once it is well established, "dollar spot" is most persistent. It is capable of killing the grass causing bare areas to appear with a consequent uneveness of the playing surface.

Because of conflicting evidence on conditions which favour the occurrence of "dollar spot", the appearance of the disease in *A. tenuis* greens on the Sydney metropolitan golf courses has been studied in relation to weather conditions. In an endeavour to determine whether the cost of treating greens using standard recommendations could be reduced, investigations into the effectiveness of various turf fungicides against "dollar spot" disease were conducted during the same period.

The diagnostic characteristics of *S. homoeocarpa* in culture are discussed.

The optimum temperature for mycelial growth was 25°C. and for the formation of sclerotia 20°C. The sclerotia germinated equally well within the temperature range 15-30°C. while some germinated at temperatures as low as 5°C.

It has been shown that the fungus is able to persist in the form of mycelium or sclerotia and that both these structures can survive the temperature conditions encountered in the Sydney area during a winter and summer.

The minimum environmental conditions necessary for the development of "dollar spot"

disease are an average weekly minimum temperature of 10.6°C. and the necessity for moisture, which may be provided by a succession of dews, at grass level. Severe outbreaks of the disease can be expected when the average weekly minimum temperature falls within the range 15-20°C.

The conditions of temperature and humidity varied between greens and golf courses within the Sydney area, and it has been shown that the temperature remains within the range 15-25°C., which is conducive to the development of the disease, for a much longer period in the immediate coastal areas than in those ten to twenty miles inland.

Mercuric and mercurous chloride, whether used separately or in mixtures were more effective than tetra methyl thiuram disulphide, zinc ethylene bisdithiocarbamate, ethoxy ethyl mercury chloride and phenyl amino cadmium dilactate, in controlling "dollar spot" disease.

It has been demonstrated that there is no apparent difference in the residual effect, on *A. tenuis* greens, between mercurous and mercuric chloride and that the latter is more effective and economic than either mercurous or a mixture of mercurous and mercuric chloride (1:1) in controlling the disease; further, that when the two mercury chlorides are applied to greens in the form of a mixture, the fungicidal effect is lowered.

There were no cumulative effects produced in the soil from repeated applications of mercuric and mercurous chloride to greens during the summer seasons over a period of four years.

The fungicide phenyl amino cadmium dilactate was able to inhibit the formation of sclerotia by *S. homoeocarpa.*

D. REILLY.

Awarded the degree M.Sc.Agr. by the University of Sydney.

Book Review

East Malling Research Station, Kent

Annual Report for 1960

The Annual report for the year ending September 1960, comprising the Administrative and Research reports, has just been sent out to Members of the Research Station Association. As usual the Research report is divided into four parts. The first of these summarizes the activities on the experimental farm, including the glasshouses and nursery. The weather conditions during most of the year were exceptionally difficult. Cold winds at blossom time resulted in poor crops of plums, cherries, and black currants but better pollinating conditions for apples and the abundant moisture supply in the summer gave one of the heaviest apple crops ever recorded at the station. The frequent rain made all fruit picking difficult.

The second part consists of reviews of the progress of research in each Section, together with lists of the papers published during the year. The items of most practical interest to growers are summarized in two bulletins at the end of the volume.

The third part, consisting of research reports, is by far the largest. High budding of apple varieties such as Cox's Orange Pippin that are susceptible to collar rot has been suggested as a means of avoiding this disease. Trials have now shown that budding Cox's at 9 or 12 in. above ground gave an equally good "take" as budding at 6 in., and resulted in taller maiden trees. Budding apples at 12 in. is therefore recommended as a nursery practice that will also eliminate scion rooting.

Frost damage investigations with several varieties of pear showed that the development of seedless fruit from frosted blossoms can be stimulated by treatment with gibberellic acid. Further research is, however, necessary before this treatment can be recommended commercially.

Trials comparing the susceptibility of a number of the main commercial strawberry varieties to Verticillium wilt diseases showed Talisman to be highly tolerant to both species of *Verticillium*. Cambridge Vigour was the worst affected variety, while Cambridge Premier, Cambridge Rearguard, Huxley, and Royal Sovereign were intermediate. In holdings where wilt is a serious problem, it is suggested that the use of tolerant varieties should be combined with other measures such as rotation of crops or soil fumigation.

When hops are machine-picked there are new risks of spreading Verticillium wilt from infected gardens. Some infected plants show no symptoms but a field experiment has shown that bine from these plants may be highly infective. Special precautions are recommended while the bine is being transported from the garden to the machine. The waste from the machine is best burnt but where this is impossible it may be carefully composted. It should not be put on to land for growing hops.

There are 18 other papers in this part of the report, including the full text of Dr. J. T. Martin's Amos Memorial Lecture entitled "The plant cuticle: its structure and relation to spraying problems".

Bulletins specially written for growers form Part IV of the report. Mr. A. P. Preston discusses the methods used in some of the main fruit growing districts in Northern Italy, which he visited in June and July on a study tour. Other bulletins describe methods of controlling Botrytis rot (grey mould) of strawberries, and compare the merits of various rootstocks for plums. In addition there are the two bulletins previously mentioned in which the progress of research in hop diseases and in fruit crop is reviewed.

The report has a useful index, and is well illustrated with photographs and diagrams. It contains lists of the Governing Members of the Society, its Executive Committee, and the research and administrative staff. It can be obtained from the Secretary, East Malling Research Station, Maidstone, Kent, price 17/6 (post free), from whom also is obtainable a short list of selected publications of the Station.

Talks

The Battle of The Fibres

Summary of address by Dr. F. W. G. White to the A.C.T. Branch, on June 14, 1961.

Very large areas of Australia are particularly suited to the growing of wool and in many of these it would be difficult to find an equally suitable and equally profitable agricultural activity. The income earned by the export of the Australian wool clip has for many years been an important element in Australia's balance of trade. The textile industry of the world has depended until recently for its raw materials on the agricultural production of wool, cotton, silk, and some other less important fibres. During the past thirty years an important new element has entered into competition with these fibres. In the 1930s, as a result of research by the large chemical companies of the world, first the fibres making use of the natural substances, cellulose and protein, and later the true synthetic man-made fibres, have come on to the market in increasing quantities. This has meant a completely new aspect of the competition which the natural fibres now have to face.

The statistics of world consumption of textile fibres during the last ten years show that there has been a continual increase in the total quantity of fibres consumed. With increasing standards of living in some countries and increasing world population the demand for textiles has increased overall. As a result, the production of the natural fibres, wool and cotton, has increased, and this increase has been easily absorbed in the textile industry, in spite of the fact that the cellulose fibres—commonly called rayon—and the true synthetic fibres have found a place in the market without displacing the natural fibres.

It must be remembered, however, that the research and development that has led to the invention of the true synthetics is of very recent origin. Some of these fibres have been on the market only for a very short period, but in spite of this the quantity of production has been increasing at a remarkably high rate. The country with the greatest production of the synthetics is the United States of America, and in that country the impact of the synthetics on the natural fibres has been most marked—to such an extent indeed that the quantity of wool consumed, particularly in some areas of the industry, has suffered a decline. Whether this is an indication of what may happen in other countries as the production of synthetics increases and the standard of living rises is, of course, the major question that wool interests face.

It is important to note the contrast between the agricultural industries that are responsible for the production of the natural fibres and the industry that has invented and is now producing the synthetics. The synthetic fibres are the result of vigorous and enterprising scientific research of a quite basic kind. The enterprise which has sponsored their introduction to the textile industry has had to face not only the task of inventing new fibres, but also the more comprehensive tasks of adapting these fibres to use by the textile industry, often by novel methods, and of introducing new textiles to the retail trade and to the public with unusual characteristics and often novel end uses. This has meant the entry of the great chemical companies of the world into all fields of research, the development of textile machinery, the development of textiles themselves, and into the field of promotion and salesmanship.

By contrast, the producers of the natural fibres have been able to rely in the past on the inventiveness and skill of the textile manufacturers in the older centres of textile production, which are at great distances from the principal centres of fibre production. The producers of the traditional fibres are only now facing the fact that it is in their interests to engage in textile research, to be concerned with the way in which their fibres are handled by the textile industry, and to have a comprehensive interest in the end products of that industry and in the sale of these products.

A review of the rapidity with which new synthetic fibres are today being invented, together with the very comprehensive developments in new methods of using these fibres, adds emphasis to this contention. There is little doubt that during the next ten years or so, as a result of the great research activities of the chemical companies, the world will see many changes in the nature of the fibres it has to offer, and great improvements in the way in which these fibres are used in the textile industry.

The plan recently announced by the International Wool Secretariat to extend and reorganize its activities on a world scale is thus of great interest and importance to Australia and to the two partners in this enterprise—New Zealand and South Africa—the two other principal woolgrowing countries. Australia

has already extensively developed research on the use of wool as a textile fibre, and in this field much has already been done to overcome what used to be regarded as the deficiencies of wool.

However, research alone will not achieve the desired objective. It is essential that the results achieved in the research laboratories be carried by technical men and by promotion experts to the textile industry of the world, and introduced to it in such a way that the results achieved can be used to stimulate the sale of wool through promotion and salesmanship.

Much has already been achieved in the United States and in the Continent of Europe by the use of such new ideas as SI-RO-SET. In the United States and Canada there are already 51 manufacturers of men's clothing using this process and it has already been of considerable assistance in the promotion of the sale of wool in those countries.

The proposal to appoint to the headquarters staff of the International Wool Secretariat a Director of Research and Technology is a most welcome step. It will be increasingly important to have an integrating and stimulating influence between the textile industry and the markets of the world, and the activities of the research laboratories, whether in Australia, in New Zealand or South Africa, or in the centres of textile production overseas.

The wool fibre has many characters which make it superior to any of the synthetic fibres. It will be extremely difficult, even for enterprising research laboratories, to invent fibres which have these characters. From a technical point of view it is quite unlikely that wool can be superseded as an important element of the textile industry. However, it is not enough to rely solely on the traditional virtues of wool as a fibre. The woolgrowing industry must be as enterprising in research, in the development of new and improved uses for wool, and in the field of competitive promotion as are its principal competitors. If this is achieved the future of wool can certainly be assured.

Lessons for us in Research and Extension From South East Asia

Mr. M. B. Spurling, Acting Chief Horticulturist, S.A. Dept. of Agriculture, in an address to the South Australian Branch.

In introducing his talk Mr. Spurling said that all too often technical aid workers in these countries failed to see beyond the point that "what they are doing is not the same as we do back home, therefore an improvement can be made by changing their ways to ours". Discussions on countries of S.E. Asia are too frequently in terms of how much they need our technical aid, with little thought to lessons we can learn from these countries.

Mr. Spurling first put these countries into perspective by clearing up some popular misconceptions about this area. The capitals of Indonesia, Malaya and Thailand, are closer to Darwin than are the capitals of some of the Australian States. Indonesia is only 340 miles from Australia at its closest point, so we should be more interested in the future of these countries than we are. Concerning population he pointed out that although there are some places such as Singapore city, Java, North Eastern India, North Eastern China and Japan which are densely populated, the overall population density is little different from that of Central Europe and in fact there are large areas of potentially productive land in S.E. Asia which are virtually uninhabited.

If agricultural efficiency is measured as actual production as a percentage of potential production, the agricultural efficiency of many of these countries does not compare favourably with countries such as Australia. The potential of a tropical climate allowing 3, sometimes 4 crops a year, and the potential of fertile soils fed by active volcanoes mean that their production per acre should be higher in most cases than it is. Even with crops such as rice, yields are often too low.

Commenting on some general lessons to be learned he mentioned the advantages of living in Australia, for example, freedom from internal strife which affects most Asian countries in varying degrees. The advantage of Christian standards of morality and honesty in our Government administration increases the efficiency of public enterprises and the use of Government funds. Good communications are essential for the effective administration and the problem of the poor communications seriously affects administration in a number of countries.

In the field of extension the bigger gap between fundamental research and the farmer in S.E. Asian countries because of standards of education, makes extension more difficult. The introduction of farmers' group representatives between the extension officer and the farmer is the solution, and the ways in which this problem was met in Malaya, Thailand and Taiwan were compared by Mr. Spurling, and the lessons for Australia were drawn from this.

Mr. Spurling then spoke of some of the research observations of interest to workers here. The effect

of ecological factors such as light, temperature, and water logging were discussed, and some important lessons were drawn in methods of propagation, variety improvement, and the value of biological control. The big problem of lack of animals in the agricultural picture in S.E. Asia was emphasised.

After outlining the standard of research in various countries Mr. Spurling concluded with the observation associated with his visit to Taiwan that it is refreshing and stimulating to look at research in a country in which research is reasonably well advanced but has developed parallel to, without close contact with our own.

Host Resistance and Parasite Control

Summary of a talk given to the Queensland Branch by Dr. F. H. S. Roberts of the Division of Animal Health of C.S.I.R.O.

Survival against infection with any disease within an endemic area depends upon the ability of the host to develop resistance. Such resistance is best known in diseases of microbial origin and has a wide application in the control of these diseases. Resistance also occurs in host parasite associations, but it is only within recent years that attention has been directed towards its value in practical control.

Cattle exposed to frequent infestation with the cattle tick, *Boophilus microplus,* provide evidence of various degrees of susceptibility both between individuals in a herd and between breeds. Some animals in a herd are always heavily infested, others remain lightly to moderately infested, and there are odd animals which carry few or no ticks at all. Brahman cattle in general carry lighter infestations than British breeds.

Resistance against the cattle tick is associated with a skin reaction to the bites of the tick, a hypersensitivity which is directed mainly against the larvae and nymphs. In an animal which has developed the hypersensitive state, infestation causes a severe irritation and many ticks are removed by the action of licking and rubbing. A papule is formed at the site of attachment and this exudes serum and many more ticks die because their feeding is interfered with or they become drowned in this serous exudate. Some animals may have an innate predisposition to this hypersensitive state. Generally speaking, the number of animals able to develop hypersensitivity and the degree to which this reaction can be stimulated is greater in Brahmans than in British cattle.

This resistant state has two possible applications in tick control:

(1) Breeding resistant animals. This would depend upon the degree to which the predisposition to hypersensitivity is heritable. Very little is known of this heritability except that hypersensitivity can be transmitted by Brahmans to their crosses with British cattle.

(2) Artificially produced hypersensitivity. This may be attempted by inoculations of extracts of tick larvae, so-called antigen. Preliminary experiments have been promising.

Resistance has also been observed in cattle and sheep exposed to natural helminth infections. It is much more obvious in cattle and, under natural conditions, gastro-intestinal helminths attain pathogenic proportions usually only in young animals. In resistant animals, there are usually relatively few mature worms and these are capable of laying only a small number of eggs; reinfections are, for the most part, prevented from developing to maturity, but may be retained within the animal in the immature form for considerable periods.

The actual mechanism of resistance to helminths is unknown. Circulating antibodies have been detected but these are not considered to be functional. It may be that the tissues in the helminths' immediate environment attain a hypersensitive state which renders the environment unfavourable for the parasite. It may be simply the excetion by the host into the environment of some substance which interferes with the parasite's metabolism.

It is apparent that all stages in the helminth's parasitic life cycle do not possess the ability to stimulate resistance to the same degree. Possibly the fourth and early fifth stages are most concerned. Research into the use of resistance in helminth control is directed along three main lines:

(1) The use of normal, infective larvae. Calves may be rendered resistant with a single dose of larvae. This method has the disadvantages that the stimulating dose may have pathogenic effects and that the adult worms which subsequently develop will contaminate the pasture with eggs.

(2) The use of x-irradiated larvae. Larvae subjected to selected doses of x-irradiation do not complete their development, but may remain as immature worms for long periods, when they stimulate resistance. The method has been successfully applied in Great Britain for lung worm and a lung worm vaccine of such irradiated larvae is available from commercial sources. Attempts to employ similar vaccines for other

species have been promising but less so than for lung worm.

(3) Vaccines based on *in vitro* cultures of helminths. This work is only in the early stages. It is based upon the presumption that resistance is stimulated by the metabolic products of the living worm and that the products have been successfully grown to the adult stage in "test tubes". Promising results have been obtained by simple vaccination of a crude mixture of worms and medium which includes metabolic products.

Should a highly efficient vaccine eventually become available, its application under Australian conditions of husbandry may present some difficulty. A polyvalent vaccine for use against the more important helminths is desirable, but this may present no difficulty. In countries like Great Britain, where animals are housed during the winter or where the winter is too cold to permit infection, the young stock would be vaccinated before exposure to infection in the spring. Here in Australia, sheep and cattle are exposed to infection all the year round and almost from the moment they are born. However, it is expected that the answer to when vaccination may be commenced will be forthcoming when the epidemiology of helminthic diseases is more completely understood.

Recent Advances in Agricultural Economics and their Significance for Agriculture

Summary of a talk given to the Queensland Branch by Dr. W. O. McCarthy, Senior Lecturer in Agricultural Economics at the University of Queensland.

I would suggest that the recent developments in agricultural economics likely to affect agriculture most are, firstly, the increased use of mathematical tools of analysis, and, secondly, the farm management approach to the individual farmer's production problems.

Mathematical Tools of Analysis

1. *Linear Programming* is merely a form of budgeting which uses an algebraic approach to determine an optimum farm plan. If a choice must be made between a large number of possible avenues or methods of production (e.g. a Darling Downs mixed farm where a number of cash or fodder crops may be grown, and different types of stock may be run) programming automatically selects the profit maximizing plan.

2. *Game Theory*. A problem facing farmers is that production decisions must be made now in the face of an uncertain future. For example, crops must be fertilized with only a vague idea of ultimate yield; a beef cattle fattener buys stock at a price dependent on an uncertain future sales value. Can any criteria be set up to help him choose wisely?

Currently, we are applying game theory to these problems of decision making under uncertainty.

3. *Production Function Analysis.* Resources (land, labour, and capital) for producing crops and livestock are scarce; hence, if profits are to be as large as possible then we must use these resources in an efficient manner. What we are interested in is maximum output for minimum input. The relationship between input and output quantities can be expressed as a mathematical equation and is known as a production function. This function is initially derived from experimental material and can then be used for prediction.

The Farm Management Approach

Currently, the philosophy we are trying to get producers to agree with and adopt is that the farm is a business and must be treated as such if both the owner and the country are to benefit. The aim of every businessman is to maximise profits and this can only be done by careful planning.

If the producer accepts the view that farming is a business, then it follows that he must work to a definite plan. Initially, he should draw up a long-term development program for the property, and in addition at the beginning of each year he should set out a farm budget for the coming season.

The significance of these methods is that they are making significant contributions to lowering costs of production, making best use of scarce resources, and indicating which sections of primary industry should be encouraged to expand. All these objectives are relevant if we are to improve or even maintain the living standards of the whole community.

Television and the Countryman

Mr. Graham White, Supervisor of Rural Broadcasts, A.B.C., in an address to the Victorian Branch.

Mr. White began by outlining the phases or stages of development of television in Australia, leading to the establishment of national and commercial stations in country districts in the near future.

All A.B.C. country programs will emanate from the Ripponlea studios. Initially these will be a retransmission of A.B.V.-2 programs, later, however, special local programs including local news and rural

broadcasts will be beamed to these country areas for transmission. Outside broadcast units will cover local events of importance for local and general transmission.

On the question of rural programs, Mr. White outlined the success which popular magazine programmes such as "Town and Country" had achieved. While there already exists a big country audience for T.V. programs, the bulk of the viewers were, as yet, city people. Hence, rural programs to date included items of interest to home gardeners and provided shopping guides in fruit and vegetables for city housewives. At the same time, existing programs reflected activity in the country, such as the wheat harvest, and mustering snow-bred cattle when such activity was taking place. Because of the real interest of city people in happenings in the country, these programs were among the most popular live A.B.C. programs broadcast in Victoria.

More serious programs, such as "Australia Unlimited" and "Farming Overseas" were presented weekly to give a picture of farming developments across Australia and from all countries of the world.

Mr. White then pointed out that all such A.B.C. programs, while informative, were designed to be entertaining to a wide viewing audience.

A special A.B.C. service on television for the countryman is envisaged. This service would include farming news, detailed weather information, brief visual summaries of stock sales, filmed highlights of major rural events, items of interest to women in the country home and material related to research and agricultural extension projects.

Mr. White related the experience overseas in such countries as Canada and U.S.A. where television was responsible for reducing attendances by farmers at agricultural meetings at night. In Australia in farming areas around the capital cities—particularly in Victoria, West Gippsland and Central Victoria—it is clear that T.V. has had a similar effect on attendances at evening meetings, particularly during winter months.

T.V. and Agricultural Scientists

Many organisations wishing to maintain close contact with the farming community however may well find T.V. a great ally. Not only is it possible to inform farmers *en masse* through news items and interviews, but the television screen offers tremendous scope for demonstrations. For instance, orchardists can see a new method of pruning demonstrated clearly on T.V. whereas at a field demonstration a group clustered around a tree cannot get the same close-up view.

On Commercial T.V. extension authorities could either buy time themselves or obtain a sponsor for a program. Rural programs are a popular feature on British and American commercial T.V.

More demands will be made in future on the time of agricultural scientists to assist and appear in rural programs on National and Commercial television. Mr. White, in reply to questions, suggested that it would be in the interests of organisations which planned to use such programmes as those envisaged by the A.B.C. for country television to have liaison officers on their staff trained in the use of the medium. One of the facts to be recognized is that the preparation of material for television presentation is most time consuming. For example, where it may take only an hour or two to prepare a radio talk, for serious T.V., such as the current "University of the Air" series, and the proposed rural programs, considerable time must be given to preparation. A half hour program may take up to a week or longer to prepare. Apart from film that may have to be shot, the person concerned will himself have to prepare scripts and supervise the preparation of graphic and demonstration material. These factors need consideration, but should not be frightening. The important point is that a television demonstration is likely to be seen by far more farmers in a half-hour's transmission than would be the case if a demonstrator travelled the countryside speaking to small groups over a period of two or three months.

Country television opens new possibilities for agricultural extension. The farmer will certainly be kept abreast of latest developments and local events and if T.V. programs are carefully prepared he will be both informed and entertained. When all Victorian stations are in operation more than 85 per cent of the population will be covered.

The Australian Institute of Agricultural Science and Rural Extension.

The New South Wales Branch held a Meeting in May to discuss the reports of the sub-committees of the Federal council and the N.S.W. Branch on Rural Extension. Mr. J. D. McFarlane, a member of both sub-committees was first to address the meeting.

It is timely for the Institute to give special attention to extension because most primary producers are now challenged to meet economic and marketing conditions by increasing efficiency of production. It is also timely because of the increasing numbers of

graduates coming forward. Furthermore, there is now more scope for applying science to agriculture and, indeed, a greater need for this application of science.

We must ask ourselves if our profession is adequately geared to the task of helping farmers and graziers with their now complex, highly capitalised, but not very profitable enterprises. This task involves more than the conveying of new knowledge to the ears or eyes of the farmer; it is not completed until the new knowledge has been successfully incorporated into production or marketing practices.

It should be noted that the growing emphasis on farm management and animal husbandry in research and extension will call for some new approaches in extension. Not only do these subjects involve a comprehensive approach to production programmes but they are subjects on which most producers feel, because of their experience, they can discuss matters on an equal footing with extension personnel; this is in contrast with their acceptance of the authority of agricultural scientists on such matters as soils, insects, diseases, fertilisers, etc.

A review of the Institute's recent activities relating to extension should begin with the report "Agricultural Scientists in Australia", published in 1959. This report pointed out that "We (the Institute) would be failing in our duty to our country and to our members if we failed to draw particular attention to the tremendous need and great scope for agricultural extension among farmers and to the role of the agricultural science graduate in this work." The report urged that extension be studied as a discipline in its own right at University level as is done in other countries where agriculture is highly developed, and stated that until this is done "there are enormous difficulties in the way of creating an adequate extension service".

Following publication of this report Committees were set-up by Council and Branches to consider what follow-up action was called for by the report. The N.S.W. committee strongly recommended that the principal follow-up action should relate to extension.

An extension Sub-Committee, appointed by the N.S.W. Branch Committee, submitted a preliminary report in July, 1960. The report was based on interviews with a number of people, some written submissions and some literature.

The Committee reported finding that extension was commonly viewed simply as the passing of technical information to the farmer, rather than as a comprehensive adult education programme.

Nobody, it would seem, doubts that extension does not enjoy prestige comparable with that of research; this in spite of general agreement that extension is just as important as research, that a high standard of professional training and competence is as essential in extension personnel as in research workers, and that extension careers offer work which can be as challenging and satisfying as any other professional work in agriculture.

The report stated that the essential elements of an extension officer's work are:

1. Adult education.
2. Interpreting research findings relating to technical and economic aspects of production.
3. Conducting field investigations and demonstrations.
4. Defining problems and referring them to research organisations.

The Committee suggested that extension officers should be mainly persons of university training because the nature of extension work is such that it calls for a high level of education and training and improved opportunities for education now permit greater numbers of able students to attend universities. Furthermore, extension is being increasingly based on the science rather than the arts of farming.

The Committee considered that for more effective extension in the future it is necessary that greater attention be given to training for extension at the undergraduate and post-graduate levels, and that more farmers' sons have the benefit of agricultural college courses, which might be modified to include more basic work and less time on practical farm work.

Another Extension Committee, appointed by the Federal Council of A.I.A.S., submitted a report in January, 1961.

One of the main tasks of this Committee was to review recent reports on Australian Extension Services. The Committee's review embraced the organisation of extension, extension methods, extension research and extension training. The Committee was aware that the value of its review was greatly reduced by the fact that virtually none of the literature covered had been written by extension workers practising their profession in rural communities. The report states that "If the Institute is to make sound suggestions on improving the standard of extension work the views of extension workers are essential, though collecting and assessing this information would be difficult".

The report draws attention to two concepts of extension. In a report prepared by A.I.A.S. in 1951, Australian extension work was defined as being similar to that in England in that its aim is "to

communicate to the farmers advice and assistance with respect to advances in knowledge and methods in technical agriculture". On the other hand there is the much broader concept prevailing in America, which is illustrated in notes used by the Queensland Department of Agriculture and Stock for training extension officers. Those notes define the aims of extension as follows:

Through the educational process:

1. To contribute to the individual development and collective welfare of people.
2. To help people make adjustments in the home and on their farms to meet changing economic and social conditions and technological developments.
3. To aid in the efficient production, preservation and distribution of food and fibre.
4. To aid in maintaining and increasing the productive capacity of the nation's soils and assist in the wise use of national resources.

In deciding what action might be recommended, the Committee kept in mind that the Institute should take care not to overstep its responsibilities in its endeavours to bring about improvement in extension. The major role of A.I.A.S. is probably to stimulate other agencies, by providing pertinent information. The key organisations to lead nation-wide changes in extension are the Standing Committee on Agriculture and the Universities. The Institute has, on several occasions in the past, prepared reports and made recommendations concerning extension, but practically no action has resulted directly from those reports.

The Committee noted also that there is a pressing need to give extension full professional status.

The recommendations of Council's Committee were:

1. that there should be big increases in teaching and research in extension
2. that A.I.A.S. should sponsor the preparation and publication of a manual of agricultural extension for Australian conditions
3. that A.I.A.S. should foster a society of extension officers
4. that A.I.A.S. should foster publication of more papers on extension. This might be one duty of a permanent extension committee of Council.

Mr. R. N. Farquhar then spoke on comparative extension. The following definition of extension is used by the Food & Agricultural Organization of the United Nations: "The term, Agricultural Extension Services, includes the services which deal directly with the farmers and assists them, through educational procedures, in improving farming methods and techniques, increasing production and income, and bettering their level of living".

As with most other public programs of adult education, agricultural extension has tended to reflect the socio-economic needs of the people, place and period. The association with the universities and colleges ensures that the educational approach remains an integral part of the basic philosophy for the work, and assists in the close association of extension and research. The counties support local extension programs, being responsible for portion of the finance, and direct the programs to solving of local problems. Local practicability of extension is thus ensured.

In U.S.A., the "whole-farm" and "whole-farm-family" approach has been assisted by the "general practitioner" base for the agricultural extension service and supported by practical local studies in farm-management economies and rural socio-economics. In England, under the new organization, the National Agricultural Advisory Service rests on the district officers. There are numerous subject-matter specialists servicing the district men. In Australia the organization now responsible for agricultural extension work grew up around "experts" and "inspectors", and was based largely on research and regulatory functions. Agricultural extension was added to the functions of these subject matter divisions at a later stage. This has led to the lack of a general practitioner base for the extension activities of the various agricultural organisations and the difficulty of fully implementing the whole-farm approach considered desirable in progressive overseas countries.

While we would all agree that more men and money are desirable to stimulate increased extension work in agriculture, investigations have shown that the number 'of full-time equivalents' extension workers in agriculture in Australia on a per-farm basis, compares favourably with progressive overseas countries. While the great contributions, past and present, of agricultural extension are fully recognised, it is suggested that the efficiency of the training and organization for extension work might be the first things to be studied objectively if Australia, as with most other countries, wished to increase the efficiency of its agricultural extension programs.

In line with those of progressive universities overseas, Australian universities are now recognizing agricultural extension as a worthy field for university research and post-graduate training. The University of Queensland has already announced firm plans for such, and others are considering such steps.

These university innovations have such important

implications for the future of professional agricultural extension in Australia, that they warrant the full support of each member of this Institute.

Animated discussion followed the main addresses with much criticism being levelled at the Council report. Discussion closed after a motion "that the Management Committee set up a sub-committee to consider and make recommendations as to what should be done to improve the farm advisory services available to farmers" was passed.

Fertilizer Trends in the U.S.A.

Summary of an address by Mr. K. D. Jacob to the Victorian Branch.

Mr. Jacob, a world authority on the chemistry and technology of fertilizers, has been visiting Australia at the invitation of the local fertilizer industry.

In his address to the Victorian Branch of the Institute Mr. Jacob surveyed recent trends in the U.S. fertilizer industry. During the last 10 to 15 years the overall fertilizer consumption has increased from 18 million to 25 million short tons, the most significant change being the increased use of nitrogen fertilizers. In 1947 the ratio of N:P:K usage was about 1:2:1; today it is more like 1:1:1. In 1959-60 2,767,000 tons of Nitrogen, 2,566,000 tons of available P_2O_5, and 2,238,000 tons of K_2O were used.

Concentrated super and ammonium phosphate now comprise 47.3 per cent of the P_2O_5 production, an increase of nearly 7 per cent in three years, while the percentage of normal and enriched super has dropped from 56.2 to 47.8. One third of the nitrogen that is used directly as a fertilizer is as anhydrous ammonia; it is applied direct or used in the irrigation water. At present only 6.4 per cent of nitrogen fertilizer for direct application is in the form of ammonium sulphate, and the production of urea has increased six-fold since 1948 to 631,000 tons.

Proportionally, less fertilizer is now prepared as mixtures, mainly because of a 20 per cent decrease in the amount of nitrogen used in mixtures. In 1957 34 per cent of mixtures were marketed in a granulated form, which reduces dust hazards and caking. In 1958-59 2,169,000 tons of fertilizer, of which 464,000 tons were in mixtures, were shipped in liquid form.

Corn accounts for one third of the total primary nutrients used, and consumption has increased with the use of higher yielding hybrid plants. Grain, cotton, hay, and pasture each use between 8 and 10 per cent of the total. Crops such as vegetables, fruit, and tobacco have always used considerable amounts of fertilizer but the relative use by these crops has in fact dropped. Gardens, lawns, playing fields, roadsides, cemeteries, etc., now account for 4.3 per cent of all nutrients used.

Northern Territory Symposium

Developments in the Mining Industry

Summary of a talk on Developments in the Mining Industry by F. King, Chief Geologist and Director of Exploration, Consolidated Zinc Ltd.

The subject of mining development of the Northern Territory is one that has been talked and written about for more than 70 years and the principal reason for talking about it again today is a general desire to see more mining activity than there is.

In 1888, an exhibition of Northern Territory products was held in Melbourne and the mineral section included gold, silver, lead, copper and tin from 45 localities. One of these localities, from which specimens of copper/silver/lead were shown, attained prominence about 65 years later. This was Rum Jungle. Many of the others are still well known and have continued to receive intermittent attention up to the present time.

Interest in the mineral possibilities of the Territory had, however, been aroused many years earlier. Gold had been found in 1869 and had first been worked in 1872, more than a decade before the discovery of Broken Hill and 21 years before Kalgoorlie. By 1887 high hopes were held for the future of the mineral industry of the Territory. Gold production had averaged about £80,000 per annum for several years; the Eveleen silver mine (later Evelyn) near Pine Creek was being compared with Broken Hill; prospecting had shown that the mineralized country extended to about 150 miles inland from Darwin; one official report stated that the Northern Territory was exceptionally rich in minerals and that the same quantity of gold, silver, copper and lead would not be found in any equal area in Australia; and the railway under construction from Darwin towards Pine Creek was described in an official report as the "Transcontinental".

In the following 70 years the number of mineral occurrences has been considerably enlarged. Lead and zinc at Bulman and near the McArthur River; tin at Maranboy; copper at Redbank, Homeward Bound, Jervois Range and south of the MacDonald Ranges; wolfram and mica northeast of Alice Springs; copper, lead and zinc at the Lander River and near Mt. Doreen; gold and copper at Tennant Creek and The Granites; native copper at Willeroo; bauxite at Gove; low-grade iron on the Roper River; one new lead and one new zinc deposit in the McArthur River area; uranium, copper and lead at Rum Jungle; and uranium in the South Alligator country have extended the area of mineral discoveries to virtually the whole of the area not covered either by younger rocks or by desert sand.

And yet, despite all its early promise, only two mines in the Territory (other than uranium) have reached sustained and significant production. Both of these are at Tennant Creek, the Nobles Nob Mine of Australian Development and the Peko copper mine. These two provide the bulk of the £4 million per annum output of metals (uranium excluded) and employ about 400 men. The uranium mines, excluded from the figures of metal production because the value of output is not completely known, employ around 500 men and another 100 are engaged in miscellaneous mining activities making a total of 1,000. Even so, the importance of its mining activities to the Territory is clearly shown by the fact that, though on this modest scale, it completely supports two of the three towns of any size outside the largely administrative centres of Darwin and Alice Springs, and its exports far exceed the value of cattle sent out of the Territory.

(Here a number of slides were shown to illustrate various aspects of Northern Territory conditions affecting the industry—aridity, isolation, lack of roads, vegetation cover, the shallow shoreline of the Gulf.)

With this background it is appropriate to examine three questions.

(a) Why has mining development in the Northern Territory been so small by comparison with other states?

(b) Has the Northern Territory the potential to produce larger deposits?

(c) What can be done about finding these?

(a) It is clear from the history and results of prospecting and from the valuable geological mapping that has been done by the Bureau of Mineral Resources that the modest development of the mining industry in the Northern Territory is not attributable to any lack of showings of minerals; nor to absence of the older Precambrian rocks which have provided most of the metals mined on this continent; nor to lack of enterprise. In my opinion, it is due principally to the fact that the prospecting that went on all over the continent from the middle of the last century until the thirties yielded better results elsewhere than it did in the Territory. Victoria had its Ballarat and Bendigo; New South Wales its Broken Hill and Cobar; Tasmania its Mount Lyell

and Rosebery; Queensland—Mount Morgan, Charters Towers and later Mount Isa; Western Australia—Kalgoorlie and the other gold mining centres. In all of these areas, prospecting yielded mines which ran for half a century or more. Many of them are still in active production. In the Territory, prior to the uranium discoveries, prospecting yielded only one mining field capable of sustained production, and that one at the maximum distance from transport and with a trying summer climate and very little water.

(b) The second question, whether the Northern Territory could produce deposits capable of substantial and sustained production, requires a rather longer answer. First of all, the big metal deposits in the eastern and southern parts of Australia were found because they were outcropping. They would not have been found by the prospectors if they had not outcropped. The fact that the yield from most mines declines with depth has been known since the earliest days of mining, but in the last twenty years or so, it has come to be recognized that ore-bodies have tops as well as bottoms. Most of the ore-bodies being mined today, which have contributed so much to the development of this country, would have been buried out of sight when the land surface was at some hundreds or thousands of feet above its present level. Therefore ore-bodies being small things, the chance of any one being exposed at the present surface is dependent on an accident of erosion. This implies that there could be worthwhile ore-bodies which do not reach the surface and which, therefore, were not found by the prospectors. Experience in other mineralized area, and even in the Northern Territory, has shown that this is so and in many parts of the world today most of the exploration that is being done is in search of these buried deposits. Even in the Territory two such deposits have been found. One is a low-grade lead deposit in the Rum Jungle area and the other a new uranium occurrence a few miles southwest of Rum Jungle. In the four areas shown on the map, namely the Pine Creek, the Bulman/McArthur, the Warramunga and the Archean of Central Australia, the Northern Territory has large areas of rock types which elsewhere in Australia or in other parts of the world have produced worthwhile ore-bodies.

I would think that the mining potential of these areas is a good deal greater than results to date indicate and the attention paid to some of these areas since the war by some of the major mining companies indicates that the potential is believed to be good enough to justify expenditure on exploration.

(c) A great deal of effort and ingenuity has been devoted, especially since the war, to developing techniques for assisting in the detection of these buried deposits, and under favourable conditions some of these techniques are of great assistance. Their range of usefulness is, however, considerably restricted by the conditions that prevail on the old Australian land surface as compared with the glaciated Precambrian shield of Canada, where they have been used with conspicuous success; and it must be fully realized that the search for these hidden deposits is long and expensive. For example, the Australian Atomic Energy Commission wisely decided in the early days of the Rum Jungle field to undertake a search for new ore whilst the outcropping deposits were being mined out. Geological mapping enabled the area of search to be restricted to the relatively small size of about 100 square miles. A new deposit was found, but only after seven years of search and of very large footage of drilling.

Whilst the techniques for indirect detection of ore and geological studies of ore occurrence may be extremely helpful, the critical phase of exploratory work is drilling, usually diamond drilling, which is the principal means of obtaining information on size and value. This has been going on in the Northern Territory in some measure for many years. Diamond drilling in the Brocks Creek district was done as early as 1908; in the McArthur River area in 1913; one of the Rum Jungle showings was drilled in 1915. Since then, diamond drilling has been done in more than twenty localities in the Northern Territory. This drilling has helped in the development of the Tennant Creek field and it has been the means of the two new discoveries in the Rum Jungle area. This is good, but there simply has not been enough of it to test the potential of the mineralized areas. There are possibly a score of localities in the Northern Territory where an effort on the Rum Jungle scale might discover a worthwhile deposit.

In mining circles, a great deal has been heard about the great mineral development in Canada since the war. As already mentioned, the surface conditions in central and eastern Canada are more favourable than they are on the old Australian land surface. Nevertheless, I feel that the greater rate of discovery there is mainly due to the intense diamond drilling activity. In Australia the footage of exploratory diamond drilling, though not known with any accuracy, is probably not more than 300,000 or 400,000 feet per annum. In Canada, it has been around 5 million feet per annum for many years. Given sound planning and proper selection of areas, I would expect that the rate of discovery would be about proportional to the footage of exploratory drilling.

An increase of drilling is therefore, in my opinion, the activity that most likely would contribute to the

development of the Northern Territory mining potential. In the last ten years or so, some of the major mining companies have extended their exploratory efforts to the Territory and one of the Tennant Creek companies is engaged in a vigorous exploratory campaign in that field. However, there is so much room for search that if the mineral potential of the Territory is to be tested in a short time, some special encouragement may be required. There are precedents for this in other fields of exploration.

To summarize then, the present position may be put this way.

The prospecting activity which the Territory shared with other mining areas in Australia failed to produce any of the large mines lasting for half a century or more which have contributed so much to the development of the country.

The search for ore deposits in the Territory is now in the next phase, i.e. the search for hidden deposits, which is difficult and expensive.

The indications of mineralization and the type of rocks found in the mineralized areas in the Territory suggest that the potential is greater than has been indicated by the results to date. The search for these hidden ore-bodies is going on in the Territory and it is thought that an increase in these activities, especially in drilling, would increase the chance of discoveries. This may, however, require special encouragement, especially in view of the high cost factors resulting from the climatic conditions and the undeveloped state of the Territory.

Pastoral and Agricultural Industries in the Northern Territory

Summary of a talk on the Pastoral and Agricultural Industries in the Northern Territory by M. J. T. Norman.

Present Cattle Industry

Along with mining, the cattle industry is the only important primary industry. At present there are just over 1 million cattle grazing on 250,000 square miles of pastoral leases and 125,000 square miles of annual grazing licences. They are predominantly Shorthorns, under extensive conditions at 3-8 beasts per square mile. The labour on cattle stations is largely aboriginal. The degree of control of stock varies but generally it is better in the centre, and there is almost none at all in the far North. There are 4 main districts—Alice, Barkly, Victoria, Darwin and Gulf.

Alice. Cattle population is 300,000 on small properties 200 to 1,000 square miles. Turn-off percentage is estimated at 18 under better management than elsewhere in Territory. Rainfall is 5 to 12 in. Top feed, particularly mulga, is important and hence the industry is relatively drought-tolerant. Watering is exclusively by sub-artesian bores. Up to 1956 this district produced fats for South Australia. Now with the lifting of the pleuro line, increasing numbers of young stores are being sent south by rail. A great advantage is the rail link with South Australia. There are no cattle ticks in this district.

Barkly. This is mainly a treeless plain with black soil and Mitchell-Flinders grasses, as well as red soil areas of top feed and some bluebush swamp.

Properties are large, 1,000 to 8,000 square miles and the cattle population is 350,000. Turn-off percentage is estimated at 13. Watering is mostly by sub-artesian bores. Fairly uniform grass feed hence vulnerable to drought. Regular dry season deficiency of N and P occurs.

Mature cattle are driven east to Queensland railheads. The area is marginal for cattle tick.

Victoria. Topographically variable. It is slightly better off than Barkly for feed. Properties are large, at 1,000 to 6,000 square miles for a cattle population of 250,000. Turn-off percentage is again estimated at 13. There is plenty of natural water, but management is difficult because of rugged terrain and distance from market is a handicap. Not as drought vulnerable as Barkly.

About 10,000 cattle per year, all mature, go to Wyndham, remainder over Murrunji to Barkly then to Queensland railheads. Cattle tick is a problem.

Darwin and Gulf. The most primitive in development. The high rainfall and low fertility soil leads to rank grass of low nutritive value, particularly in dry season. Regular severe deficiency of N and P in dry season. There is plenty of natural water. Properties are small at 200 to 2,000 square miles. The cattle population is 200,000 with an estimated turn-off percentage of 10. Management is difficult, and until recently there was no market. Recently a small trade in live cattle to Manila and Hong Kong has developed. Tick and Buffalo fly are severe.

Present Agricultural Industry

In contrast to cattle, the present agriculture is very small.

- Small area of mechanised rice growing on the sub-coastal plain. 5,000 acres in 1959/60, 2,000 acres in 1960/61. Yields low.
- Local horticultural production Darwin region, Katherine river levee, Alice Springs. Mainly dry-season irrigated vegetables and also tropical fruit—bananas, pawpaws, mangoes, pineapples,

citrus, tomatoes. Does not supply full needs of Territory. Date production around Alice Springs.

Present Agricultural and Pastoral Research Projects

(a) *Alice Springs.*
C.S.I.R.O.
- Dryland exotic pasture establishment.
- Physiology of arid zone plants.

Northern Territory Administration Experimental Farm.
- Large-scale testing of findings of C.S.I.R.O. station.
- Recording of costs of farm systems.

Northern Territory Administration Animal Industry.
- Beef cattle nutrition on mulga and spinifex.
- Irrigated lucerne production.
- Poison plants studies.
- Nutrition studies on Barkly Tableland.
- Recently, tropical cross-bred cattle.

(b) *Katherine.*
C.S.I.R.O. Research Station.
- Dryland arable agriculture—Peanuts, Cotton, Sorghum.
- Beef cattle fattening on sown pastures and fodder crops.
- Physiological and soil physical studies. Soon tropical cross-bred cattle.

This work aims to develop an intensive land-use system for 30-40 in. rainfall zone.

(c) *Adelaide River.*
Northern Territory Administration Agriculture Branch.
- Irrigated rice and pasture on Marrakai plains.
- Non-irrigated legume pastures.

(d) *Darwin.*
C.S.I.R.O.
- Agronomic problems of rice production at Humpty Doo.

N.T.A. Agriculture Branch at Beatrice Hill.
- Integration of rice growing with beef cattle fattening.
- Berrimah—vegetables, fruit and pastures.

N.T.A. Animal Industry.
- Buffalo industry research.

Mr. Norman suggested as possible future research in the Northern Territory—

(a) *Alice Springs.*
C.S.I.R.O.
- The prospects of introduction of exotic pasture grasses not high. Possible future lines are—
- Utilisation and management of native vegetation.
- Irrigated crop and pasture production in limited areas.
- Work on cotton, dates, lucerne.

N.T.A.
- Clearly a large field in cattle nutrition in arid zones. General future of the district could involve steady improvement in knowledge on management of native vegetation and possibly intensive irrigation development of small areas.

(b) *Katherine.*
- Peanuts apparently unlikely to be grown extensively in area in near future.
- Intensification of work on cattle fattening. This is quite different from Alice and there is likely to be a revolution from cattle hunting to intensive fattening of stores from Victoria and Barkly, not merely steady improvement on present industry.

  Work is urgently needed in higher rainfall areas (40-60) for pasture production.
- Intensification of work on cotton as possible cash crop in place of peanuts.
- Probable development into centre for fundamental work on monsoon agriculture.

(c) *Adelaide River.*
- On Marrakai, rice dubious, except in rotation with pastures as in the Murrumbidgee area in N.S.W.
- Early results on sown pasture production (Townsville Lucerne and Phasey Bean) are very promising indeed. Extensive work should be encouraged, as this district offers better and cheaper pastures than Katherine region.

(d) *Darwin.*
- Only limited progress likely in rice on Coastal Plains unless whole system of farming changed to ensure proper weed control and controlled establishment of crop.
- Possibility of work on pastures in adjoining upland areas.
- Para grass requires more intensive examination.

Description of the Territory

Summary of a talk by W. Granger, Officer-in-Charge, Primary Industries Branch, Department of Interior.

It is a century next year since John McDouall Stuart crossed the continent, and the continuous history of settlement began with the selection of Palmerston on Port Darwin as the site for the chief town in 1869—92 years ago.

In these nine decades, particularly in the last two, a great deal has been done to catalogue and describe the Territory's resources.

The topographic map (Northern Territory of Australia, Topographic, 1:2,000,000 NMP 51/148, available from Department of Territories, Canberra, 5/-) shows an area about 1,000 miles from north to south and 580 miles from east to west, comprising 523,620 square miles. This is one-sixth of Australia. Four-fifths of it are north of Capricorn.

The coastline is generally flat and low, and is indented by inlets and bays over its length of 1,040 miles. Port Darwin is an excellent harbour although the great rise and fall of tides, which averages 20 ft., creates minor problems. The earliest settlements in the 1820's and 30's were all on the sea—Fort Dundas, Raffles Bay, and Port Essington. The Imperial Government intended these to develop as armed outposts and trading centres (first with the Malay praus which fished trepang) along the lines followed by Singapore and Hong Kong. The motives of the South Australian Government, to which the Territory was annexed in 1863, in establishing settlements at Adam Bay, 1864, and at Port Darwin, 1869, were more closely identified with agricultural and pastoral development, and with integration of the area with the south—the overland telegraph line was built in 1870-72 and the railway from Darwin to Adelaide was commenced in 1878.

Behind the coast generally there are mud flats and flooded country. The country fairly gradually rises to a water shed at about 1,200 ft. within which numerous rivers run northward to the coast. The longest are the Victoria and the Daly, each 340 miles. The Roper, 220 miles long, drains the largest area, 19.4 m. acres. The Adelaide, 100 miles long, is not among the ten longest rivers. A part of the Territory adjacent to Western Australia drains into the Ord, and a part could be irrigated from the scheme on that river. The rivers are used for navigation.

The sub-coastal plains south of Van Diemen's Gulf are the site of a major rice project. Since this land was first seen in 1839 by Wickham, who appreciated the possibilities for rice-growing on the plains each side of the river, and taken up for sugar-planting by the Adelaide River Land and Sugar Company in 1881-2 it has presented a challenge to Australian agriculturists.

The greater part of the remainder of the Territory is an almost perfect plain, rising to about 2,000 ft. in Central Australia, broken by a few mountain ranges in Central Australia and by rock outcrops in the south-west. It is the result of practically uninterrupted erosion.

For administrative purposes Central Australia and North Australia were once divided through the latitude of Barrow Creek Telegraph Station. The Territory is now divided into four statistical districts which more or less correspond to the regions evident on the topographic map: Darwin and Gulf, the Barkly Tableland, the Victoria River District, and Alice Springs or Central Australia.

The MacDonnell Ranges and associated ranges run East-West for 150-200 miles in a strip about 20-50 miles from north to south. They give Central Australia the strange beauty of vivid colours which is painted by Batterbee and the Aranda artists. They are weathered down to almost bare rock rising generally to no more than 1,500 ft. from the plain or 3,500 ft. above sea level. Black and white photographs ("The Northern Territory". A series of 30 pictures in an information folder, prepared and published by the Department of Territories, Canberra. Free on application.) do not do justice to them, nor to Ayer's rock, one of the three Great Tors to the South West of the ranges which is a monolith of 6 to 7 miles in diameter and 1,100 ft. high, composed of a brilliant red conglomerate of water-worn granite boulders and a hard quartzite which has weathered like polished terrazzo.

The Barkly Tableland is an almost perfect plain, nearly treeless, grassed like a wheat field or bare according to season, with horizons like the ocean and a character of permanence and stability derived from the absence of folding since pre-Cambrian times.

From eastern Arnhem Land a rugged area of pre-Cambrian rocky ridges passes to the north and east of the Barkly Tableland and provides the mining fields of Mount Isa and Cloncurry in Queensland.

The Daly River and the alluvial and estuarine deposits of the north are important agricultural areas discussed later.

The mineral deposits will be discussed by Mr. Haddon King. Gold was discovered in 1872 by parties working on the overland telegraph. The gold rush and railway construction peak population of 7,533 in 1888 was not reached again until 1940.

It has become trite to say that the Territory is a land where water means life, but south from the watershed of the northern rivers—which more or less corresponds to the zone between the 30" and 20" isohyets—there is little permanent surface water, and it is dreadfully true that water means life.

Fortunately there are water resources under the surface, and the regions providing the best pasture are the best endowed with sub-surface water. Most of the cattle of the Territory depend on these resources for 3 to 5 months in normal years. Some three-quarters of the 57,000 square miles of the Barkly Basin of sub-artesian water is in the Territory; it provides good water at 150 to 400 ft. In the

Victoria River District the location of bores is rather more difficult. There are artesian and sub-artesian water, and water not under pressure in faults and the like and in sedimentary basins. Some quite good bores are obtained at 70 to 80 ft. In Central Australia there are small storages, and it is only recent surveys by the Bureau of Mineral Resources which have shown they may be more extensive than was thought. The Great Artesian Basin underlies 40,000 square miles of the Simpson Desert and a small area in the extreme north-east. In the vicinity of Darwin groundwater tends to diminish seriously in the dry. In the Top End generally supplies can be obtained at 100 to 200 ft. and small-scale irrigation is possible.

The cost of pumping is of course a factor in irrigation. A stock bore on the average costs £3,000 to sink and equip. Since the first bores in the Territory were sunk in 1891 and 1892 at Rocklands and Alexandria stations, the number of wells and bores in the Territory has risen to about 2,000. Following on geological survey work by the Bureau of Mineral Resources and hydrological work by the Works Department, the Water Resources Branch was formed in 1955 to survey the water resources of the Territory and to plan their development and use. The Director administers a scheme commenced recently whereby the Government assists in locating sites for bores, finances them on easy terms, and bears the cost of "duds". The Forster Committee has pointed out to the over-optimistic that there are not large volumes of water for use in irrigation which will "save the north". The Director of Water Use has pointed out to the pessimistic that the Territory's cattle production need not be kept to its present level by the scarcity of surface water as there are unknown and untapped basins awaiting assessment, and this resource is "obviously great but unknown".

The first of C.S.I.R.O.'s four surveys (C.S.I.R.O. Land Research Series No. 1. Survey of the Katherine-Darwin Region 1946) which have now covered practically all the important agricultural and pastoral parts of the Territory was of the Katherine-Darwin Region. The land systems of most interest agriculturally at present were described in this survey: the sub-coastal plain, the Marrakai and the Tipperary. The sub-coastal plains, not more than 20 ft. above sea level, traverse the lower portions of the Adelaide and other northern rivers which are meandering tidal mature streams, with distributories, billabongs and salt water backwaters. They are flooded for part of the year. The soils are estaurine plain clays and in the swamps, which are often associated with spring-fed streams, there are estaurine plain peats. The major rice-growing enterprise and research are based on Humpty Doo on the adjacent higher ground of the Koolpinyah land system.

The Marrakai land system occurs as irregularly shaped areas along the middle courses of the rivers and comprises level to slightly sloping plains intersected by large mature water courses with low levees, and interspersed with low gravelly or stony rises. Lying between the ridges the acid alluvial soils which powder, were well-known to soldiers as "bulldust". The Administration has experimental rice areas of these soils.

The Tipperary land system is the drainage basin of the lower Katherine and Daly Rivers with a gently undulating surface interspersed with outcrops of limestone and sandstone, Cambrian sedimentaries. The soils are variable. Tippera clay loam and sandier soils are represented in the experimental blocks of the Katherine Research Station and the Experiment Farm. A survey is in progress to assess in greater detail the distribution of the soils of this land system as a basis for planning land use and detailed soil surveys and mapping.

The Administration has an experiment farm at Berrimah, eight miles from Darwin, on the red laterised soils of the Charles Point land system.

The annual rainfall diminishes from 55 to 60 in. in the north to about 5 in. in the south-east corner. The south-east trade winds dominate; they last most of the year in the south, and all over the Territory April to September is the dry season. The summer rainfall comes with moist tropical air in the north-west season and progressively diminishes, away from the coast. There are also tropical cyclones, and south of Tennant Creek winter rainfall associated somewhat indirectly with the winter movement of lows across southern Australia.

Ranges in Temperature — Fahrenheit degrees.

	Darwin		*Alice Springs*		*Melbourne*	
Extremes recorded	104°	50°	117°	19°	114°	27°
Monthly mean						
Maximum	92°	86°	95°	66°	78°	56°
Minimum	78°	67°	69°	38°	58°	42°

In Darwin temperatures are equable. Looking at the normal mean temperatures for the months, the variation is only between 92° and 86° for maximum readings and 78° and 67° for readings of minimum temperatures; corresponding figures in Alice Springs are 117° and 19° for extremes, 95° and 66° for monthly maximum readings and 69° and 38° for minimum readings. By comparison in Melbourne the extremes are 114° and 27°, and monthly mean readings range from 78° to 56° (maximum) and 58° to 42° (minimum) (see table).

Mean relative humidity readings (9.00 a.m.) in Darwin are 80% in February and 59% in July; in Alice Springs 34% and 49%.

Annual evaporation in Darwin is about 80" and in Alice Springs about 100".

Most people find summer in Darwin enervating and the dry season weather very pleasant. Alice Springs has a glorious winter climate, and the summer though hot is dry. Throughout the Territory amenities such as fans and refrigerators and suitably constructed houses and offices are essential to pleasant living and efficient work.

C.S.I.R.O. is carrying out fundamental work on agroclimatology. The Bureau of Meteorology opened an office in Darwin last year and plans to establish there an Institute of Tropical Meteorology.

Soils of interest not so far mentioned are the grey or brown soils of heavy texture on the Barkly Tableland and the headwaters of the Victoria River (the green Mitchell grass areas of the map), (Pasture Lands of the Northern Territory, in Perry, R.A. 1960, C.S.I.R.O. Land Research Series, No. 5) and arid-zone soils which could be considered in small scale irrigation ventures; the latter are the red sands and clayey sands of the sand plains and dune fields (the pale yellow hard spinifex areas of the map), the red earths with red clay sub-soil, and alluvial soils.

A prominent feature of the pasture map is the extensive area of rugged country (brown, 94,400 square miles) and light carrying country (yellow, spinifex, 221,200 square miles and white, spear grass, 23,700 square miles) a total of some 340,000 square miles or two-thirds of the Territory. A critical appraisal of the usefulness for grazing of the best of the spinifex is now being made on a block north-west of Alice Springs by the Animal Industry Branch of the Administration.

In the northern upland region, where the rainfall is 30" or more, typically there are open woodland Eucalypt forest, tall growing perennial grasses such as perennial sorghum and kangaroo grass, and some annuals such as Sorghum intrans. The amount of the timber cover depends on the rainfall. The grasses make quick vigorous growth in the wet, and are low in nutrients in the dry.

The treeless plains as well as the sub-coastal plains are the Mitchell grass areas in the heavy soils below 25" annual rainfall. During the dry, the spaces between the tussocks are bare, but in the wet they are filled with annual grasses and herbage. Blue bush, and Chenopodium that tastes like fish meal, are valuable feed in the swampy parts of the tableland. From about Tennant Creek southward top feed of various species of Acacia plays an important role—short grasses and herbage are valuable but occur only when rain is plentiful.

From 1950 the Forestry and Timber Bureau surveyed the forest resources of the Territory. (Bateman, W., 1955, Forestry in the Northern Territory, Forestry and Timber Bureau, Govt. Printer, Canberra.) Four broad classes of forest were described: the open eucalypt producing little commercial timber, patches of cypress pine on light soils within the eucalypt forest, pure stands of paper bark on swamp lands and along streams, and small patches of rain forest. In addition, about the 25" rainfall zone are scrubs of lancewood and in the areas of 20" rainfall and below are mulga (Acacias to which I have referred), casuarinas and, along the water courses, river red gum. In 1958 the Bureau commenced a five year programme of establishing test plantings of exotics and testing measures for conservation of the indigenous forests; also assistance is being given to the development of forestry on aboriginal reserves. At the end of five years a forestry branch may be established in the Administration.

The Territory is an area of vast distances and long communications. The population of the Territory is now approximately 38,000 of whom an estimated 16,800 are aborigines. Darwin's population is 10,000 and that of Alice Springs 3,000. The South Australian Government, as I have said, began the trans-continental railway in 1883 by constructing the line from Darwin to Pine Creek which was completed in 1889. The Commonwealth assumed control of the Territory in 1911 and between 1914 and 1917 extended the line to Katherine, and then in 1929 to its present terminus near Birdum. This was in pursuance of the *Northern Territory Acceptance Act* 1960 which stated that the Commonwealth should "construct or cause to be constructed . . . The Transcontinental Railway". Also in 1929 the Central Australian Railway was extended from Oodnadatta, in South Australia, to Alice Springs. A gap of 619 miles still remains. There are some 12,000 miles of roads and tracks in the Territory of which the bitumen highways, the Stuart 954 miles and the Barkly 280 miles, account for 1,234 miles.

Mr. Hasluck has said that the Government's aim is to develop an integrated road system for northern Australia as a whole, and in the Territory to maintain the existing roads and provide ten key feeder roads to the highways of a standard suited to the motor transport of cattle.

Since the Animal Industry Branch was established in 1946 to take over from the Army Veterinary Corps, stock routes have been improved and developed to a plan which aims at providing for the movement of stock in stages with not more than 16 to 20 miles between watering points, and such that young cattle and cows could be turned off. Apart from road development, facilities at rail points are being provided for integration of road trains and railways in the movement of cattle. Modern yards have been built on Darwin wharf for the live cattle export trade. (The Economics of Road Transport of Beef Cattle: Northern Territory and Queensland Channel Country. Bureau of Agricultural Economics (W. T. Allen) 1959.)

You can leave Melbourne by plane about 8.00 a.m. most days of the week and be in Darwin for dinner, and planes provide an excellent network of internal services.

Public expenditure is made both under the Northern Territory vote by the Administration, and by various Commonwealth Departments which have functions in the Territory; e.g., the Department of Health and the Department of Works. Expenditure is also made under the Commonwealth vote by departments which have Commonwealth-wide functions such as the Departments of Navy, Army, Civil Aviation and Postmaster-General. The expenditure under the Northern Territory vote during 1959/60 was about £10m. of which £6.2m. was administrative expenditure and £3.9m. was for capital works and services. The total Government expenditure of £19m. in 1960/61 compares with £6m. in 1950/51, and over the ten years the total public expenditure was £127m.

Private investment in pastoral, agricultural and mining industries over the past ten years has probably been twice this.

The main economic activities of the Territory are the beef cattle industry, mining, and to a much lesser extent, agriculture. Cattle production for many years has been the most stable of these, although in the value of annual production it is now exceeded by mining. In the last ten years the value of cattle production has increased from £2¼m. in 1949-50 to £4½m. in 1959-60. Over the same period the value of mineral production, excluding uranium, has increased tenfold to £6½m. in 1959-60.

At the outset I said I would try and give something of the atmosphere of the Territory. This is very difficult — to some people the Territory is a sleeping giant requiring only investment and enterprise to multiply its cattle production several fold, which will involve intensive agricultural development in the higher rainfall areas and the development of irrigation elsewhere, and exploitation of its rich mineral wealth. To others, it is as a bottomless sink for public funds; the failure of agricultural experiment farms and meat-works in the early days of Commonwealth administration only shows that enthusiasm is not enough to make things succeed in the Territory.

There are people of both camps in the Territory today, and in the heat, encountering the frustrations that occur at the end of the supply line, at the lack of understanding of public or civil employers in the south, with the knowledge that economic conditions outside the Territory have a great deal to do with its own economy, the atmosphere of defeatism is sometimes dominant.

But the heat can be offset by reasonable living conditions and amenities; the failure of the experiment farms can be explained by the directions which were given before they were even established that they should pay their way; the failure of the meatworks can be explained by the unexpected, fantastically high capital cost due to the outbreak of war while they were being built; economic appraisal can show the lines of development which offer the best prospects in the Territory; and supply problems and lack of understanding and appreciation down south are being overcome—this spirit also is encountered in the Territory. It is significant, I think, and possibly symbolic that the firm which built the meatworks, so long a monument to despair, has now begun to build abattoirs in Darwin and has said that it contemplates entering into the export of beef.

Future of Northern Australia

Summary of a talk on The Future of Northern Australia by C. S. Christian, member of the Executive of C.S.I.R.O.

In competing on the future of Northern Australia one might first ask the question—"Why is there all this interest in Northern Australia and its development?"

It is worthwhile examining this point because the degree of interest will surely be a major factor in influencing its future.

One can recognise a number of factors which might create this interest—

(1) There is no question about the undeveloped nature of Northern Australia at the present time. The very sparse population (less than 100,000 in about a third of the continent), the absence of intensive agriculture and the very sparse nature of the cattle industry present clear and obvious evidence of this.

But being undeveloped is no crime. There are lots of undeveloped areas in the world, even within those countries which are densely populated.

(2) The world, and Australia in particular, is well aware of the vast populations north of Australia in the eastern half of Asia and of the rapid increase in this population that can be expected in the near future. The existence of a large undeveloped area contiguous to such increasing populations is unquestionably a cause for uneasiness.

But an increasing population does not necessarily imply an expanding one geographically. I think we might forget for the time being at least any suggestion that these expanding populations will of their own accord provide a threat of invasion to Northern Australia. Peoples of these areas are not so keen on migration to new environments. In many cases they have resources of their own yet to develop and probably in many instances this could be done more readily and more cheaply than attempting to establish outposts in Northern Australia.

The danger does not lie in these people voluntarily wanting to occupy Northern Australia, but they could be talked into believing that they wanted to. The backing of great powers wanting to embarrass Australia could easily establish embarrassing situations for this country in international councils. This perhaps is the greatest danger arising from the populations to our north.

(3) The third factor is the possibility of obtaining economic wealth from Northern Australia.

It is certainly not an eldorado but it has substantial resources about which we now have considerable information. It offers some possibility of diversification in Australian production and possibly in export.

The development of natural resources would provide an opportunity for an increase in Australian population, perhaps not of any very great magnitude but nevertheless of significance in our aim of reaching what might be called an adequate minimum for the support of our own industrial development.

(4) Northern Australia is closest to the Asian areas and, looking into the future, if it is possible to develop the resources and to produce exportable products, this geographic location may be a factor of significance.

As the Asian populations grow there must inevitably be an increased demand for goods. If Northern Australia can supply some of these, then we have the opportunity of developing a new geographic region perhaps based on new markets adding to our wealth and adding to our eventual security by effective occupation.

The establishment of firm and satisfactory relationships between this country and those areas to the north of us is surely something of considerable importance to Australia, and direct trading from Northern Australia could contribute to this.

(5) Summarising this aspect—

Our interest in Northern Australia lies largely in several aspects of its future importance in the Asian-Australian setting—its future importance as a contributor to our economic wealth and the contributions that it can make to increasing our population to the adequate minimum.

In Northern Australia, therefore, we have an interest which is not limited to the immediate welfare of any settlers who may happen to occupy land there. It is a forward looking interest in the future and, because of this, it is a nation's interest not just the interest of the participants in development. The extent to which the nation recognises its interests will determine how rapidly and, because time may be a factor, how far Northern Australia develops under Australian control.

What then are the resources of Northern Australia and the possibilities of economic wealth?

The resources are substantial areas of arable land, areas with adequate rainfall for dry land agriculture, vast quantities of water with possibilities of conservation and irrigation, and substantial mineral deposits.

Briefly, the possibilities of production revolve around mining, cattle and crops; placed in this order not because of any order of priority but because the letters "M.C.C.", which will be known to some of you, may help you to remember them.

Added to these resources is the very substantial body of facts which have been established about the north which enable us to think much more clearly about its future possibilities than has been possible in many other areas in Australia before development started.

Some of the forms of production which have been shown to be possible, and not only possible

but possible at levels equal to or better than other areas where these things are being produced commercially now, have doubtful economic possibilities in the immediate future.

For example: While sugar cane production at high levels of sugar per acre per annum is possible under irrigation in the Ord River Valley, the present market problems of sugar are such that the initiation of sugar growing in that area in the near future is unlikely.

But looking into the future, who would care to be dogmatic there may not be room for the production from another mill area of sugar cane. If such scope arises we should certainly keep the Ord River Valley in mind for the compact nature of the area would certainly be very suitable to the establishment of a sugar cane industry.

Then too, there have been doubts thrown upon the markets for peanuts or peanut oil—another crop which it has been shown is a natural for the region, producing high yields and requiring no irrigation.

I am not sure that we are not jumping to conclusions about peanuts.

We really have very limited data on the true costs of production or the contributions that peanuts could make in a mixed farming system. I would think we need to try before condemning this crop in the immediate future or for later development.

Beef would appear to have more satisfactory marketing prospects.

Cotton, providing it can be produced at a cost which does not call for a substantial subsidy such as is required by the existing cotton industry in Australia, could make a very worthwhile contribution as an import saving crop.

There are other possibilities too—rice and various kinds of oil crops—and it must now be revealed that Northern Australia *is* capable of substantial agricultural and pastoral production, and we already have ample evidence of the productive wealth of its mineral resources.

How can we mobilise these resources for our development?

Here we must clearly recognise again the two points of view—that of the individual settler with limited finances who has to show a profit in order to survive—and that of the nation which by investment at this stage might lay the foundation for a development of major economic significance in the future.

In recognising these two points of view we come up against one of the major factors which has retarded and will retard the development of the north unless some special aid is given.

The economic environment of the north is that of an undeveloped country

—It has no substantial local markets.

—It has limited transport facilities.

—It lacks long-term experience of production in most fields.

—Its own economic wealth is inadequate to provide the basis for its own development.

—And, because of the lack of production, it does not have the market contacts or the marketing routine of the developed areas of Australia.

This stage of development is its biggest handicap, and the need to bridge this gap in services, facilities and economic advantages is perhaps the greatest problem. It is a problem which, if left to the private individual utilising land or mineral resources, must certainly condemn the north to a very slow rate of development.

If the north has to pull itself up by its own bootlaces, it not only will take a long time but it is questionable whether it will get its feet off the ground.

What then is necessary?

(1) The establishment of the economic possibilities of the various forms of production which have been shown possible.

(2) Continued research and prospecting to establish new forms of production (agriculture and forestry).

The future of the north should not be limited to what we know now, even though this does appear to be a great deal.

Pilot phases of development will be an essential part of this economic proving period. These pilot phases should be pilot developments and not pilot farms—for a pilot project has to be sufficiently large to measure the repercussions of development on other forms of production and on communities.

Furthermore they have to be sufficiently varied and flexible to encourage the development of farming systems from the various possibilities of production that exist. This is not something that can be expected to emerge from a government pilot farm.

During this stage assistance must be assured and general if a self-sustaining system is to emerge.

(3) The examination of those forms of production, which are not quite economic in their own right, to see what measures would be feasible to permit their successful development.

Armed with this information and experience and our knowledge of the phyical resources in the north, thought should be given to the general planning of development.

In this respect we must recognise that the Northern Territory cannot stand alone.

Beef cattle are transported interstate, and the development of cattle roads has interstate implications—so some kind of planning for the north as a whole is necessary.

Transport will serve a number of industries—port facilities must be developed to suit the production from various regions.

In other words, there needs to be some kind of integration of development, some kinds of priorities established, and these affect the whole of the north, not just the Northern Territory.

Whether this be done by some kind of interstate agreement or the establishment of some kind of Northern Australia Development Authority, is not important. The main point is that a degree of integrated planning is essential.

Coupled with this too must be a special effort in seeking out markets specifically for Northern Australian products.

News Items

Northern Australia and Trained Scientists

Speaking in Sydney after his return from an investigation of the potential of the North, Mr. J. G. Beale, M.L.A., Chairman of the Water Research Foundation of Australia, said that many more scientists and engineers trained in water engineering will be needed in the near future if the Northern Territory is to be quickly and wisely developed.

Water presents major problems to Australia and although Universities are conducting research on some of these problems with assistance of the Water Research Foundation they are having difficulty in getting suitable research fellows. This, coupled with the need to develop Australia, gives young engineers and scientists an unprecedented opportunity of specialising in hydrology and hydraulics.

It is very pleasing to hear that the University of New South Wales is to run a Water Engineering Course again this year to meet the demand for hydrologic engineers. Last year, the special course on Water Engineering was attended by twelve engineers and scientists from New Zealand and all States of the Commonwealth. In the twelve weeks they studied climatology, meteorology, runoff, drainage, flood forecasting, flood estimation, flood mitigation and other topics in hydrology. They inspected water projects, industries and research work, conducted seminars and became conversant with the latest ideas in the control and use of water. The course was so successful that the Water Authorities who sponsored some of the students asked the University to run it again.

This year's Course which started on August 28 is even more comprehensive than the previous one as it will benefit from the experience overseas of Professor C. H. Munro, Head of the School of Civil Engineering and Director of Research of the Water Research Foundation. Prof. Munro, in his 15 months in Europe and North America, had the opportunity of studying latest methods and research and will lecture at the course.

This type of course is to be highly recommended to engineers who want to specialize in hydrology and is a unique opportunitiy to acquire the latest techniques and knowledge in Water Science over a twelve week period. As the development of Australia is vitally dependent on water and trained scientists are urgently needed, such educational programmes are highly commended by the Foundation.

Queensland Wheat Research Institute

A contract, amounting to almost £100,000, has recently been let for the construction of buildings for the Queensland Wheat Research Institute at Toowoomba.

Preparations for the foundations have been commenced and the buildings are expected to be completed by May, 1962. The foundation stone was laid by the Minister for Agriculture and Forestry, the Hon. O. O. Madsen, M.L.A., at a ceremony on September 2, 1961.

Food Preservation Research Laboratory

This Laboratory was officially opened by the Queensland Premier, Mr. F. Nicklin, M.L.A., in July, 1961.

The history of the Laboratory dates back to 1945 when the Queensland Department of Agriculture and Stock was reorganized and, as part of the Horticulture Branch program, research was commenced on the storage, transport, and processing of fruits and vegetables grown in Queensland. The facilities available for this research were extremely limited and most of the experimental work had to be conducted in commercial storage rooms or in conjunction with canneries.

Built at a cost of £150,000, with another £30,000 for equipment, the Laboratory covers an area of about 10,000 sq. ft. Immediately behind it is an area of about three-quarters of an acre which has been reserved for Departmental purposes to provide for future expansion.

On August 4, 1960, a Food Preservation Research Branch was created, with Dr. S. A. Trout as the Director. The present staff at Hamilton consists of physiologists, chemists, food technologists, microbiologists, laboratory technicians, a processing assistant, an experimentalist, and laboratory attendants. There is now a staff of 26 who will be augmented from time to time to cope with the many urgent

problems requiring investigation. Initially, research will be on fruits and vegetables, but work on other foods will be undertaken at a later date.

The cold storage block consists of two low-temperature storage rooms, an air-blast freezer, and two lots of four rooms above freezing point, separated by a refrigerated ante-room. The eight cool rooms and the ante-room are refrigerated by calcium chloride-brine, forced-draught coolers. The ante-room is kept at about 38°F to prevent condensation, while other rooms are maintained at 30°, 32°, 34°, and 36°F for deciduous fruits, 45° and 50°F for citrus and tropical fruits, and 65° and 85°F for ripening purposes.

In addition to the cold storage block and various laboratories, there is a modern processing unit for experimental work in freezing, canning and dehydration.

A turbulent-film evaporator, complete with a volatile flavour recovery system, is being installed for the production of frozen or pasteurized concentrated fruit juice.

The Laboratory is divided into four main sections —Physiology, Chemical, Microbiology and Food Technology.

The Physiology Section will be concerned with developing improved methods of storing, transporting, and ripening Queensland horticultural crops, in order to eliminate much of the wastage which takes place between the producer and the consumer. It is also hoped to determine whether it is possible to export to distant markets a greater variety of Queensland-grown fruits and vegetables.

The Chemical Section will be concerned with changes in stored and processed foods, particularly fruit quality, which is so important in the marketing of a foodstuff.

The Microbiological Section will be concerned with the identification and control of spoilage organisms in fresh and processed foods, and with developing methods for the utilisation of fruit residues.

The Food Technology Section will concentrate on improving methods of canning, freezing, and dehydrating fruits and vegetables, developing a wider range of tropical fruit products, and on producing on a semi-commercial scale a number of pure fruit juice concentrates.

Land Survey, N.T.

A team headed by Dr. N. H. Speck, plant ecologist, of C.S.I.R.O. Division of Land Research and Regional Survey is re-surveying the Tipperary Land System in the Katherine area at the request of the Northern Territory Administration. N.T.A. is interested in the development of improved pastures and cropping in the area. The team, which includes R. H. M. van der Graff (soils), R. L. Wright (geomorphology) and M. Lazarides (taxonomy), will be in the field from July to October.

Increased Levy for Wool Promotion

A joint meeting between the Australian Wool Bureau and the two major bodies representing woolgrowers —the Australian Woolgrowers' & Graziers' Council and the Australian Wool & Meat Producers' Federation—agreed on July 5 to increase the wool promotion levy from 5/- to 10/- per bale.

The agreement will stand for 12 months and will be reviewed by the three bodies no later than March next year.

The increase in the wool levy will be used for promotion and research work through the newly reconstituted International Wool Secretariat.

Wool Bureau 25 Years Old

Legislation to establish the body now known as the Australian Wool Bureau was passed by the Commonwealth Parliament on July 1, 1936, and the first meeting took place in Melbourne a fortnight later.

The Bureau began as the Australian Wool Board, and it was not until its reconstitution in 1953 that it became a Bureau.

Australian woolgrowers first began to move for promotion of their product in 1925—long before the term "man-made fibres" was coined. The very low return from wool during the depression years accelerated promotion thinking of growers, and as a result, in 1936 grower organisations took action which culminated in the formation of the Australian Wool Board.

The first wool levy struck by the Board in July, 1936, was 6d. per bale, 3d. per fadge or butt, and 1d. per bag.

First Chairman of the Board was Mr. G. Dalziel Kelly (later Sir Dalziel Kelly).

Within days of their first meeting, the Board decided to seek a conference with New Zealand and South Africa to consider a co-operative publicity scheme. Representatives of the three woolgrowing countries met in Melbourne in January, 1937, and agreed to set up an International Wool Publicity and Research Fund.

Delegates of the three countries urged the establishment of a full-scale research programme.

At the same time they warned of the coming dangers from synthetic fibre production which was described as being "very effectively organised and with immense capital resources."

The work of the Australian Wool Bureau now covers many fields—some of them relatively unknown even to woolgrowers.

These include the Wool Stores Administration section which controls 312 wool warehouses throughout Australia.

The Bureau also controls a Wool Statistical Service which provides information to wool interests throughout the world on a scale unequalled by any other primary industry.

The Bureau does not handle a pound of greasy wool, nor does it market a single garment or one yard of fabric.

Its entire promotional activities are solely dependent on its ability to win the co-operation of textile mills, manufacturers, wholesalers and retailers, and by publicity to attract the general public to the fibre it promotes.

C.S.I.R.O. Advisory Council

The Advisory Council of C.S.I.R.O. recently held its twenty-third meeting in Canberra. This Council, which is composed of thirty outstanding men from industry, agriculture, and the universities, is a little-known but very important body. It was set up by statute in 1949, and at its two meetings each year gives to the C.S.I.R.O. Executive the benefit of its advice on matters concerning the program of research of the Organization. Members serve in an honorary capacity.

Members of the Council represent a wide range of interests and represent all the States of the Commonwealth. The Chairmen of the six State Committees of C.S.I.R.O. are members of the Council, and they bring to the deliberations of the Council well informed views from their home States. Membership of the Council is not static, since members must retire after a maximum of two three-year terms. This ensures a constant inflow of new men and new ideas at meetings of the Council.

Apart from its value as an advisory body, the Council has rendered an especially valuable service to C.S.I.R.O. in undertaking at regular intervals reviews of the various specialist Divisions and Sections of which the Organization is composed. These reviews are undertaken by sub-committees of the Council, composed of members of Council and other people co-opted because of their special knowledge of the field. The reports of these sub-committees are a most useful guide in planning future research.

Increased Beef Cattle Research

The beef cattle industry, along with other primary industries, has recently decided to impose a levy upon itself to provide funds for scientific research into the problems which face it. The levy decided upon is two shillings per beast slaughtered, which, together with a matching Commonwealth Government grant, will produce a sum of £600,000 a year. Although research funds will not become available until later this year, C.S.I.R.O. has already planned a major increase in its work for the industry.

Major expansions in four fields of work are proposed. Firstly, there is to be an increased effort in veterinary research, aimed at the elimination of such pests as the cattle tick, which still costs the cattle industry some £10 million each year. There is to be more research into methods of controlling tick fever, and infertility caused by Vibriosis. An improved longer-lasting vaccine for pleuropneumonia will be sought.

Research into the proper feeding and nutrition of cattle will be mainly directed to the summer rainfall areas in northern Australia, where there is great scope for pasture improvement. This work, in which the Queensland Department of Agriculture and Stock is also concerned, may enable large tracts of land in Queensland, the Northern Territory, and the Kimberleys to carry many more cattle to the acre. The effort here will be concentrated on the provision of

new and better pasture species, either introduced from abroad or bred in Australia, and well adapted to the conditions in our northern cattle country.

C.S.I.R.O. cattle breeders will increase their efforts to identify the hereditary characters which seem most desirable for cattle to flourish in the northern heat. Existing herds of British breeds and Zebu breeds from Asia provide a wide range of different characters, and research will try to establish just which of these characters should be incorporated in future herds.

Finally, the quality of the beef carcase will be given special attention by the Division of Food Preservation, C.S.I.R.O. The Division plans to study the handling of cattle just before and during slaughtering, believing that this can affect beef quality. The research on the effect of conditions of storage and transport on quality will be continued.

Land Survey in New Guinea

At present New Guinea is not producing enough food for its own requirements. If the country is to achieve a greater measure of independence self-sufficiency of food supply must be the first goal in its agricultural development.

Agriculture in New Guinea is not a stable thing. Normally the natives are continually on the move, burning clearings in the forest, planting and harvesting crop gardens, and then moving on again to do the same thing elsewhere.

If stable agriculture is to be established, the first step is to find out which areas of land have the best agricultural potential, so that permanent farming communities can be established. Only after this has been done can roads and markets be logically planned.

After the war, C.S.I.R.O. developed unique methods of land survey which have been successfully used for rapidly taking stock of land resources. Since 1953 these methods have been applied in New Guinea, and six large tracts of New Guinea land have already been investigated. The surveys begin with the aerial photography of a whole region. From the photographs it is possible to recognize recurring patterns of land which are called land systems. Each of the many land systems is then closely studied in the field by teams of specialist scientists. The field studies in New Guinea have been particularly arduous, as the scientists have had to negotiate steep mountains up to fifteen thousand feet in height, forest, jungle and swamp.

The work done so far has produced results of great value and interest. Some first-class agricultural land has been found, as well as much more land which is capable of improvement. It has also been found that some of the areas of best agricultural land carry little or no population.

Part of C.S.I.R.O.'s job is to make recommendations as to how New Guinea's land resources can best be used.

As the existing pattern of shifting agriculture is replaced by stable agriculture, crop rotations to maintain soil fertility will be essential.

Apart from recommending that this hill country should be used for timber growing, and that grass plain should be used for cattle raising, C.S.I.R.O. is also looking at the possibilities for land improvement. Some of the country can be easily improved by grading and ditching for drainage, while other land can only be used profitably after major flood control or reclamation projects are carried out.

Australia is pioneering this field of land survey in the tropics. Although F.A.O. is now using a similar approach with one scientific specialist in Central America, and more specialised agricultural surveys are being made in a number of countries, Australia's work in New Guinea is virtually unique.

Careers of Graduates

Thirty-one students graduated in Agricultural Science from the University of Queensland in 1961. Their present employment is:

Full-time postgraduate studies	7
Department of Agriculture and Stock	14
(five of whom have enrolled for part-time postgraduate studies)	
C.S.I.R.O.	1
Department of Agriculture, Stock and Fisheries, Territory of Papua and New Guinea	4
Private Enterprise	1
Farming	1
	28

The other three were overseas students, and have returned to their respective countries.

ENROLMENTS IN AGRICULTURAL SCIENCE COURSES

	1961				
	Year of course				*Completed course in* 1960
	1	2	3	4	
University					
Adelaide	34	18	12	12	15
Melbourne	53	34	59	46	42
Queensland	59	44	32	33	31
Sydney	103	41	47	33	47 (+ 3 B.Ag.)
Tasmania	7	—	—	—	—
West. Aust.	35	20	12	13	13
Totals	291	157	162	137	148 (+ 3)
Associated courses					
Wool Tech. (N.S.W.)	11	9	9	3	4
Rural Sc. (New Eng.)	45	33	22	19	11
Ag. Econ. (New Eng.)	27	10	6	5	—
Ag. Eng. (Melb.)	—	—	3	2	2

ANIMAL PRODUCTION

JOURNAL OF THE BRITISH SOCIETY OF ANIMAL PRODUCTION

Contents of Volume 3, Part 3, October, 1961

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WALKER, E. A. and TAYLOR, J. H. — Effect of parenterally administered iron upon the growth of piglets.

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Personal Notes

Australian Capital Territory

Miss Nancy T. Burbidge of C.S.I.R.O. Division of Plant Industry has been awarded a D.Sc. by the University of Western Australia. She is one of Australia's leading herbarium taxonomists and recently published a monograph on the phytogeography of Australian flora.

Mr. A. V. Hill of Microbiology Section, C.S.I.R.O. Division of Plant Industry, Canberra, left on July 6 at the urgent invitation of the Greek Government to advise on measures to defend the Greek tobacco industry against the ravages of blue mould. This serious disease has spread through Europe only in the past two years.

Mr. E. S. Hoffman, Assistant Director, Bureau of Agricultural Economics, returned recently from overseas. He attended four conferences in six weeks mainly in Rome attending meetings of FAO Committee on commodity problems and FAO Council as member of the Australian delegation led by Mr. A. C. B. Maiden, Director of the Bureau. Last year Mr. Hoffman spent six months in Asia as Australian Representative on the Wheat Utilization Mission to Japan, India, and Indonesia studying problems of the utilization of surplus foodstuffs in the economic development of those countries.

New South Wales

Mr. G. A. Alexander formerly with C.S.I.R.O. at Prospect has left for Cambridge where he will further his studies in animal health.

Mr. K. Marshall has completed his studies for the degree of Doctor of Philosophy at Cornell University, U.S.A., and is returning to Australia where he will join the Meteorological Branch of C.S.I.R.O. Perth. Mr. Marshall before going overseas was with the N.S.W. Dept. of Agriculture.

Dr. C. J. Magee, Chief of the Division of Science Services of the N.S.W. Dept. of Agriculture has returned from his trip around the world, where he attended meetings of the Commonwealth Agricultural Bureau and the Mycology Institute. Dr. Magee addressed the N.S.W. Branch on some aspects of his trip at the Branch's April meeting.

Mr. L. J. Durham formerly with the Soil Conservation Service at Cooma has transferred to C. P. Bird and Associates, Perth, W.A., where he will act as agricultural adviser.

Mr. K. Russell has moved from Wilcox Mofflin Ltd. to Geigy Agricultural Chemicals Pty. Ltd. which has recently begun activities in N.S.W. Also with Geigy is *Mr. A. R. Murphy* who graduated from Sydney University in 1961 and is now carrying out field research in herbicides.

Queensland

Messrs. W. W. Bryan and N. H. Shaw of C.S.I.R.O., St. Lucia, have left for overseas on long service leave. Travelling independently, both plan to visit the United Kingdom, Europe, and U.S.A.

Mr. A. R. Stobbs of the Colonial Service of Africa, a soil surveyor, who is spending six months in Australia, visited during his stay in Queensland, Dimbulah, Theodore, and Burdekin Valley irrigation areas. Mr. Stobbs plans to use locally gathered information in an irrigation potential survey of Nyasaland.

Another recent visitor from Africa was *Mr. R. A. Robinson,* a plant pathologist of the Scott Agricultural Laboratories, Department of Agriculture, Nairobi. This institute is engaged in research on plant pathology and *Rhizobium.* Mr. Robinson spent some time with Dr. Norris of C.S.I.R.O. studying *Rhizobium* with particular reference to tropical legumes and the problem of nodulation in African *Trifolium* spp. He is principally concerned with building up *Rhizobium* studies in East Africa.

An Indonesian F.A.O. Fellow, *Mr. M. E. Serigar,* an agrostologist from the Bogor Agricultural Research Institute, is on a study tour in Queensland. He has found much to interest him amongst the

tropical legumes and grasses and has spent some time with the Department of Agriculture and Stock, making trips to Biloela, Ayr, Ingham, South Johnstone, and the Atherton Tableland. Recently he spent some time with C.S.I.R.O. officers in the Brigalow country and at Cunningham Laboratory, St. Lucia.

Mr. A. Johnson of the Dept. of Agriculture and Stock has been transferred as chemist to Parada Experiment Station in North Queensland. He will carry out soil and plant analysis associated with the station's experimental programme.

Mr. G. Ettershank has been appointed Government Entomologist at Samoa. Mr. Ettershank was previously an Entomologist with the Department of Agriculture and Stock.

Queensland delegates to the Australian Tobacco Research Conference held in March at Canberra were *Messrs. A. W. Winterton, F. Chippendale, W. Pont, B. A. T. Rodda and G. Saunders* of the Queensland Department of Agriculture and Stock, and *Dr. W. W. Goodall* and *Messrs. W. J. Lovett* and *J. M. Wheatley* of C.S.I.R.O.

Mr. J. H. Smith has been appointed Director of Horticulture in the Department of Agriculture and Stock.

Mr. T. McKnight left on March 11 on a six month trip to U.S.A., Canada, and the United Kingdom to investigate various aspects of pathological and other problems of cereals. Funds for the trip were provided by a Wheat Industry Research Fund.

Mr. B. T. Egan, Pathologist of the Bureau of Sugar Experiment Stations stationed at Meringa, spent six weeks recently as Colombo Plan adviser on sugar diseases and pests to the newly established sugar industry in Ceylon.

Dr. W. O. McCarthy, Senior Lecturer in Agricultural Economics at the University of Queensland, attended a Farm Management Conference in New Zealand in August.

Mr. I. Romano, a recent graduate of the University of Queensland, has been appointed Plant Breeder at the Department of Agriculture and Stock's Hermitage Experiment Station.

Dr. J. Griffiths Davies, in the company of *Mr. R. Jones* and *Mr. A. Eyles,* has made a three-week survey of the beef cattle regions of Queensland's Gulf Country.

Dr. M. C. Franklin, well-known for his work on animal nutrition in the south, has moved to the Cunningham Laboratory of C.S.I.R.O. to undertake further work in this field.

Mr. C. R. Von Stieglitz, Agricultural Chemist, of the Department of Agriculture and Stock, retired on June 30 this year.

Mr. J. Hegarty, Agrostologist, Division of Plant Industry in the Department of Agriculture and Stock, has been appointed Assistant Standards Officer in the Division of Marketing.

Other staff changes in the Department of Agriculture and Stock are: the transfer of *Mr. D. Purcell* to Blackall as District Agrostologist to work on district problems including development of Gidyea country and control of Sandalwood; the transfer of *Mr. P. Luck* to Cooroy as District Agrostologist to work on problems of Dairy pastures; the transfer of *Mr. J. M. T. Marley* to Warwick as Agronomist, specializing in winter cereals; and the appointment of *Mr. D. Bailey,* a New Zealander, to Kingaroy as Agronomist to work on problems of weed control.

Dr. R. W. Downes has returned to the Department of Agriculture and Stock from Cornell University, U.S.A., where he obtained his Ph.D. in Plant Breeding and Genetics. Dr. Downes is at present engaged in a survey of State plant breeding problems, with particular reference to pasture species.

Bureau of Sugar Experiment Stations Assistant Director, *Mr. L. G. Vallance,* and Research Chemist *Mr. K. C. Leverington,* left Queensland towards the end of August to spend 3-4 weeks in Hawaii. Their mission was to obtain information on the latest Hawaiian fertilising trends. Recent recommendations from Hawaii outlining the value of soil analyses are of considerable interest since it is on this basis that the Bureau has made its own recommendations for so many years.

South Australia

Dr. J. L. Dillon from the Agricultural Research Liaison Section, C.S.I.R.O. Canberra has joined the staff of the Economics Department, University of Adelaide. He will be associated with Dr. F. G. Jarrett, who returned from 12 months overseas late in 1960, in presenting the course in Agricultural Economics.

Mr. W. G. Allden, who recently returned from 12 months' study leave has completed his M.Ag.Sc. thesis and has been appointed Mortlock Fellow as Senior Lecturer in Animal Production in the Agronomy Department at the Waite Institute.

Dr. T. J. Marshall, who recently represented Australia on the Council of the International Society of Soil Science at Madison, Wisconsin, has returned after 8 months in U.S.A. and Europe.

Mr. J. H. Silsbury visited the Welsh Plant Breeding Station at Aberystwyth shortly after arriving in London, and is now undertaking a research project at the University of Nottingham under the direction of Prof. Milthorpe.

Mr. P. D. Hooper retired on April 14 from his position with the C.S.I.R.O. Soils Division after about 31 years service.

Messrs. *D. G. Edwards, K. G. Theng* and *D. Muljadi* (Soil Science), *A. G. Basson* and *Miss D. Taty* (Entomology) have completed their Honours degrees and are proceeding towards their Ph.D. degrees. Miss Taty from Indonesia had the honour of being Adelaide's first woman graduate with the ordinary degree and now is the first with B.Ag.Sc. Hons.

Mr. J. C. Radcliffe has completed an Honours degree and has recently joined the S.A. Dept. of Agriculture as a Research Officer under a grant from the Commonwealth Dairy Trust Fund.

Dr. C. G. Stephens of C.S.I.R.O. Soil Division, Adelaide, has been invited by F.A.O. to be a member of the Committee appointed to produce a World Soil Map. This committee met on June 19 in Rome. Dr. Stephens left Adelaide by air on June 16 for a period of 3 months.

South Australian Branch members who attended the recent A.N.Z.A.A.S. conference in Brisbane included *Professors C. M. Donald* and *R. K. Morton, Drs. R. J. Best, M. C. Buttrose, N. C. Crowley* and *C. G. Stephens,* and *Messrs. D. E. Symon* and *K. H. Northcote.*

Mr. G. Kolar left the Australian Wine Research Institute, Adelaide, on June 10 to take up an appointment in the Chemistry Department of the National University, Canberra.

Professor R. K. Morton of the Agricultural Chemistry Department, Waite Agricultural Research Institute, attended the A.G.M. of the Academy of Science at Canberra in April. He left Adelaide on August 4 to take part in the Symposium on Respiratory Enzymes at the 5th International Congress of Biochemistry in Moscow. He will return on September 1, after visiting Amsterdam, London, New York, Palo Alto (Stanford University), and Sydney.

Mr. R. G. Dent, Adviser in Entomology in the S.A. Department of Agriculture, has returned home to Maryland, U.S.A. He is to take up an insect pathology research fellowship granted to him by Maryland University.

Mr. R. L. Dodman has been appointed Research Scholar in the Plant Pathology Department, Waite Institute, under a Commonwealth Wheat Grant for investigations in Wheat Root Rot.

Mr. J. V. Jacobsen, Horticultural Research Officer, S.A. Department of Agriculture, left Adelaide in July on 3 years' study leave to undertake a Ph.D. degree course at Davis, California. He will investigate physiological aspects of storage and transport in the Division of Vegetable Crops at the University of California.

Mr. J. R. Goode, previously in charge of Whyalla Dairies, with F.A.O. in British Guiana and latterly at Kybybolite Research Centre, has taken up the appointment as Officer-in-Charge of the S.A. Department of Agriculture's Turretfield Research Centre. Members at present overseas include *Mr. K. P. Barley* who has moved on to Paris from California,

Dr. L. H. May, who fell and dislocated his left wrist in Europe has arrived safely in the U.S.A., and *Mr. T. C. Miller* is in England inspecting shipments of Australian fruit on arrival, on behalf of the Australian fruit industry.

Victoria

Two members of the Victorian Branch of the Institute were honoured by the Queen in the recent Queen's Birthday Honours List. They were *Mr. P. Ryan,* former Director of the Victorian Department of Agriculture, who was awarded the Imperial Service Order (I.S.O.); and *Mr. A. V. Lyon,* former Officer-in-Charge of the C.S.I.R.O. Station at Merbein, who was made a Member of the British Empire (M.B.E.).

Dr. W. R. Lang, head of the Textile College, Gordon Institute of Technology, Geelong, has had the Degree of Doctor of Science conferred on him by the University of Western Australia. Dr. Lang's thesis was entitled "The Biophysics, Physics and Physical Technology of the Australian Wool Fibre".

Professor H. C. Forster was awarded the Farrer Memorial Medal for 1961 for outstanding service to Australian Agricultural Science. His oration "The Potential for Agricultural Settlement in the Northern Territory" was given at the State Congress of the Agricultural Bureau of New South Wales at Hawkesbury Agricultural College on July 11.

Mr. K. Loftus Hills, senior writer of the Agricultural Research Liaison Section of C.S.I.R.O. and editor of "Rural Research in C.S.I.R.O.", left Australia on July 20 for U.S.A. and England to study developments in liaison publications.

Mr. P. F. Butler, Assistant Secretary of C.S.I.R.O., left for London early in July for two years' duty as Australian Scientific Liaison Officer.

Mr. L. Cozens, of the Farm Survey Research Branch, Department of Agriculture, will spend the 1961-62 academic year at the Cornell University, U.S.A., engaged in post-graduate study in agricultural economics and farm management.

Dr. I. Molnar, of the Soil Conservation Authority, will be in the United States at the same time as a visiting Associate Professor in agricultural economics at the Rhode Island University.

Miss B. Foord, librarian of the Department of Agriculture, has returned from the U.S.A. where she worked for 12 months at the Albert R. Mann library at Cornell and visited other general and agricultural libraries.

Mr. A. N. Waite, Honorary General Treasurer of the Institute left Australia in June for an overseas trip.

Dr. R. N. Farquhar of the C.S.I.R.O. Agricultural Research Liaison Section recently gained his doctorate degree for work in agricultural education. The degree was awarded by the Cornell University, where Dr. Farquhar studied on a Ford Foundation fellowship. He also travelled in Europe to prepare his thesis on the ways by which research results find their way into farming practice.

Branch Notes

New South Wales

At the 26th Annual General Meeting of the N.S.W. Branch the following office-bearers were elected:

President—Dr. B. G. Davey.

Immediate Past President—Mr. C. I. A. Beale.

Vice-President—Mr. K. R. Green.

Secretary—Mr. R. McLeod.

Assistant Secretary—Mr. R. W. Condon.

Treasurer—Dr. O. G. Carter.

Assistant Treasurer—Miss P. Spencer.

Principal Delegate—Mr. C. I. A. Beale.

Sub-Editor—Mr. P. A. King.

Auditors—Mr. L. N. Balaam (one still to be appointed) P. M. Houlahan.

Committee Members—Messrs. D. L. Jackson, D. McCallum, F. C. McMullin, J. B. Truscott.

The President for 1960, Mr. C. I. A. Beale gave his address entitled "Extension, a Philosophy, a Science and a Profession".

In August, the Branch held a residential seminar entitled "Environment in Relation to Agricultural Research". The seminar was held over three days and many problems created by the effect of the physical environment on plants, soils and animals were discussed. To enable members attending to gain most benefit from the seminar the number attending was limited to 40. Professor W. Collis-George, Professor of Soil Science at Sydney University, presented a review paper on the soil aspects and Mr. G. Moule of C.S.I.R.O. Division of Animal Physiology, Prospect, N.S.W., dealt with the animal aspects.

Queensland

The 26th Annual General Meeting of the Branch was held at Cunningham Laboratory, St. Lucia on March 29.

The Office-Bearers elected for 1961 were:

President—Dr. G. Wilson, Department of Botany, University of Queensland.

Senior Vice-President—Mr. W. J. Cartmill, Regional Experiment Stations, Department of Agriculture and Stock.

Junior Vice-President—Mr. F. Chippendale, Plant Nutrition Section, Department of Agriculture and Stock.

Secretary—Mr. F. From, Department of Agriculture, University of Queensland.

Assistant Secretary—Mr. J. Harbison, Regional Experiment Stations, Department of Agriculture and Stock.

Treasurer—Dr. W. O. McCarthy, Department of Agriculture, University of Queensland.

Committee Members—Mr. C. S. Andrews, Division of Tropical Pastures, C.S.I.R.O.

Mr. S. Marriott, Agriculture Branch, Department of Agriculture and Stock.
Mr. O. W. Sturgess, Bureau of Sugar Experiment Stations.

Sub-editor—Dr. B. R. Champ, Entomology Branch, Department of Agriculture and Stock.

Mr. F. Chippendale, the retiring President, delivered his Presidential Address "Soil and Salt".

The program sub-committee has planned a series of talks for 1961 which follow a basic pattern; speakers from certain agricultural sciences will discuss progress in these particular fields of study and their importance in agriculture.

The first of the series was given by Dr. W. O. McCarthy, Senior Lecturer in Agricultural Economics at the University of Queensland, who spoke on "Recent advances in agricultural economics and their significance for agriculture". This meeting was held at the Cunningham Laboratory, St. Lucia, on May 3.

The next of the series was given also at the Cunningham Laboratory on June 28. Dr. F. H. S. Roberts of the Division of Animal Health of C.S.I.R.O. spoke on "Host resistance and parasite control".

The July meeting continued with an address, "Decision making in farming", by Professor D. W. McElwain, Professor of Psychology at the University of Queensland.

The usual Ordinary General Meeting scheduled for May was replaced by a Sherry Party held during the A.N.Z.A.A.S. Conference to welcome Section K (Agriculture and Forestry) visitors to Brisbane. Some 200 members and guests attended the very successful function.

South Australia

Dr. H. P. Schapper, Reader in Agricultural Economics at the Institute of Agriculture, University of Western Australia spoke on "Farm Management Advisory Services, Farmers and the A.I.A.S." at the Branch Meeting, which was well attended by both members and public on February 24.

The Branch Prize for 1961, for the most distinguished student completing the course in Agricultural Science in 1960, was presented to Mr. D. W. Puckridge R.D.A. at the Branch Meeting in April. He recently commenced an honours degree course in the Agronomy Department of the Waite Agricultural Research Institute.

At this meeting Mr. M. B. Spurling, Acting Chief Horticulturist, S.A. Dept. of Agriculture, gave a well illustrated address on "Lessons for us in Research and Extension from South East Asia".

The Grassland Society of Victoria

The Society held its second annual conference at Burnley Horticultural College, Melbourne, on May 22-23. The theme on this occasion was "Some aspects of pasture management".

Officially opening the conference Mr. F. M. Read, Director of Agriculture, paid tribute to the pioneers of pasture development in the state, by whose efforts such large areas of productive grasslands have been made possible. He stressed the importance of pastoral production to our economy and urged that we should keep going "straight ahead" with grassland research.

The conference program was designed to discover the chief management problems existing today and then to discuss them as fully as possible. Speakers representing the dairying, sheep and beef cattle industries discussed their own enterprises and highlighted their own particular problems of grassland management. Then pasture officers of the Department of Agriculture discussed aspects of pasture management from both the improvement and utilisation viewpoints.

This led on to informative discussion between farmers, scientists and technical people, considered to be a major function of conferences held by this society.

The conference proceedings were published recently.

Annual General Meeting

The second annual meeting was held on May 22. Mr. M. Piggott, a fat-lamb producer of Balnarring was elected President for 1961-62 and Mr. R. J. Newman, Agrostologist, Department of Agriculture, was elected Vice President.

Other committee members are as follows—

Immediate Past President—Mr. R. D. Croll.
Hon. Secretary—Mr. R. R. Hedding.
Hon. Treasurer—Miss G. R. Easton.
Hon. Editor—Mr. G. W. Hexter.
Committee Members—Mr. W. A. Beattie, Mr. G. J. R. Coles, Mr. J. M. Fyfe, Mr. R. D. Langley, Mr. K. Schoeffel, Mr. W. MacG. Troup, Mr. N. M. Tulloh, Mr. R. L. Twentyman, Mr. H. Williams.

Tribute was paid at this meeting to the very fine work of Mr. R. D. Croll as Inaugural President of the Society. Under his wise and enthusiastic guidance the Society has made vigorous development in its two years of existence and is soundly based for continued service to all whose interests lie in grassland husbandry.

Publications

The Society has now produced its first "Grassland Bulletin" entitled "Molybdenum Deficiency in Victoria". It is the first of a series of bulletins to be issued on a quarterly basis covering all aspects of grassland farming.

The society has made inscribed folders available for purchase by members and this will enable the bulletins to be kept safely, and an informative Grassland Notebook to be built up.

The Society gratefully acknowledges a grant of £400 from the Commonwealth Bank of Australia through its Rural Credits Development fund, and a donation of £150 from the International Harvester Company of Australia towards publication activities.

Information about the Society may be obtained from the Secretary, 226 Clarendon St., East Melbourne, C.2, Victoria.

BANANAS

The origin of the banana is lost in history but it is known that, when the victorious armies of Alexander the Great swept across the Asian continent to the Valley of Indus in 333 B.C., the troops were sustained by the bananas which were growing there in profusion. Although not discovered for centuries, it was the vitamin content of the fruit which kept the soldiers healthy.

In Australia today the banana industry ranks second only to citrus in production value of fruit and in 1960 amounted to approximately £4.5 million. New South Wales grows about 85 per cent of the crop. In 1946 production in New South Wales was 1.6 million cases compared with 3 million last year. At present, all bananas grown in Australia are consumed locally.

By using good cultural practices and applying adequate fertilisers some growers are achieving yields of over 500 cases per acre per annum or about five times the average yield for New South Wales. For top yields, three or four dressings each year of mixed fertilisers supplying nitrogen, phosphorus and potash in the right proportions are essential.

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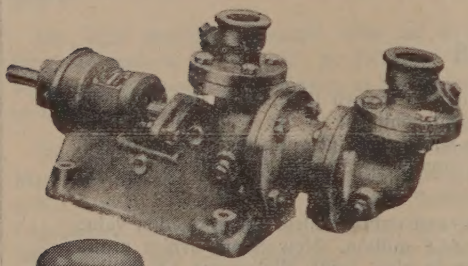

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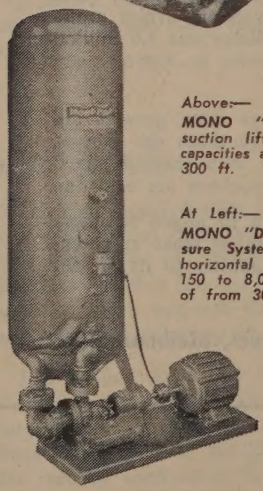

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MP61/11

PUBLIC SERVICE OF SOUTH AUSTRALIA

Applications for the following position, marked confidential and addressed to the Public Service Commissioner, Education Building, Flinders Street, Adelaide, will be received until and including 30th SEPTEMBER, 1961.

PRINCIPAL

Roseworthy Agricultural College

Applicants should state full names, address, date of birth, marital status, academic qualifications, practical experience, and give particulars of war service (if any). The Appointee may be required to contribute to the Government Superannuation Fund.

SALARY RANGE: Minimum £2850, Maximum £3160 per annum.

DUTIES: The Principal is responsible for the direction, control and administration of the College, including the discipline, welfare and training of students, and the planning of experimental work, plant and stock breeding activities. He may also be required to undertake some teaching.

QUALIFICATIONS: Applicants must submit evidence of ability to organize and control staff and students, and should be graduates in Agriculture, Veterinary Science or Science.

ACCOMMODATION: A house is available for which a rental is charged.

Further details and conditions of employment may be obtained, on application, from the Public Service Commissioner, Adelaide.

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